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FISH MEAL FOR BACON HOGS[1]

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The purpose of this paper is to present, in as concise a form as possible, an outline of the experimental feeding trials with bacon hogs conducted at Nappan during the past fifteen years, wherein fish meal has been compared with various other protein supplements. To make this report of greater value to the reader, brief summaries of some of the work conducted at other institutions are included, together with a bibliography, which although incomplete, may be of some value to those interested in further studies along this line.

DEVELOPMENT OF THE FISH MEAL INDUSTRY

It has long been recognized that sea products are among the most important sources of those constituents, both organic and inorganic, which make up the diet of man, as well as that of domesticated animals. These products are rich in both quantity and quality of protein, are valuable for their vitamin supply, as well as the quantity and variety of the minerals they contain.

Experiments were conducted in Germany as early as 1874 on the use of fish residues for feeding sheep, but there was apparently little of it used for livestock feed until after 1892. In that year, the Norwegian Government conducted the first extensive feeding trials to ascertain whether fish waste, converted into a meal, was a suitable feed for farm live stock. The results were so satisfactory that its use rapidly increased among continental farmers.

In Great Britain, it was not until about 1905 that any serious thought was given to this source of revenue from the fishing industry. A considerable quantity was manufactured during the next decade, the greater part of which was exported to the continent. Not until the World War restricted the importation of feeding stuffs from the Colonies did the British farmers seriously consider the possible value of fish meal as a source of protein and minerals for their live stock requirements. One of the earliest English investigations was conducted in 1913 at Seale-Hayne College. However, to Crowther, then of Leeds, and Orr of Aberdeen, together with their associates, goes the credit of conducting the work which finally convinced the farmers of Great Britain that this product was worth as much to them as it was to the farmers on the continent.

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Canada, like Great Britain, was slow to realize that in their coastal waters they had a valuable product from the standpoint of livestock feed. Experiments were first conducted at the Central Experimental Farm, Ottawa, in 1915. The results of these early investigations were reported by Archibald (2) about 1918, and his summary of the results were as follows: "Generally speaking, a good brand of fish meal, when judiciously fed, is not only a most profitable feed in milk and meat production, but is also a splendid appetizer and has no detrimental effect on the flavour of the meat or milk."

Fish meal was used as a livestock feed at Nappan for swine and poultry for several years previous to 1923. The product used was high in fat content, and difficulty was experienced with taint in both meat and eggs. In 1923, and again in 1925, supplies of an English manufactured fish meal below 7% in fat were secured. Since that time, fish meal of Maritime Province manufacture has been used entirely.

In 1935 and 1936, experiments with fish meal were also conducted at the Dominion Experimental Station at Fredericton, N.B. The results of these will be referred to later in this paper.

FOOD CONSTITUENTS IN FISH MEAL

The importance of a liberal supply of protein and minerals in the rations of growing and producing animals is recognized. Protein is required for the building up of lean meat and the repair of tissues, while an adequate supply of mineral matter, particularly calcium and phosphorus, is essential for bone development.

Fish meal is rich in both protein and minerals and is composed almost entirely of the materials required for growth. The vitamin and fat content varies according to the kind and quality of raw material used in its manufacture. There is no fibre in fish meal, due to its animal origin.

Proteins

Rarely, if ever, do fish meals, properly manufactured, contain less than 55% protein. Those manufactured from white fish will, as a rule, contain from 60 to over 70%. This protein, as shown by Orr *et al.* (69), is highly digestible, the pig being able to utilize more than 90% of the intake. The "quality" of the protein, or amino acid content, is even more important. Fish meal is recognized as being particularly high in the amino acids essential for growth and production, about 20 of which are known to be utilized for these purposes. Those foods which contain proteins most closely resembling the proteins found in the animal body will produce the greatest live weight increase per unit of food intake. Proteins of vegetable origin are incomplete in their amino-acid composition when compared with proteins of an animal source. A small quantity of protein of animal origin will offset this shortage, and it is for this reason that such supplements as milk, tankage, blood meal, fish meal, etc. are fed.

In the production of bacon hogs, a high "maturity index" or rapid weight increase is the aim, in order to produce the highest quality of product. It is, therefore, very essential that protein of high biological efficiency be supplied. Available data indicate that the protein of fish meal stands very

high in this regard, equal to that contained in skim-milk and possibly superior to protein from other animal sources.

Many experimenters believe that this "quality" factor is of prior importance in accounting for the improved rate of gains secured when fish meal is introduced into the ration of growing pigs.

Minerals

Fish meal contains from 18 to 22% minerals, mainly tricalcic phosphate, and composed of about 10% of lime, 9% phosphoric acid, 1.2% potash and 0.5% chlorine—Wood and Woodman (103A).

The beneficial results secured from fish meal may, to a large degree, be attributed to its mineral content. This is borne out by the results secured at Nappan where crippling has seldom occurred when the ration contained 4% or more of fish meal. Crippling has occurred among winter-fed hogs when skim-milk or tankage has been used as the protein supplement. It has, however, been much more frequent with skim-milk than with tankage. By adding a mineral supplement to the ration this trouble has been overcome.

It is pointed out by Orr *et al.* (69) that the calcium-to-phosphorus ratio in fish meal is very similar to that in sow's milk, and is about the same as is required for growth.

The advisability of adding a mineral supplement to the ration containing fish meal is debatable, but depends in any case on the amount of fish meal it contains. Woodman (103), recommended a mixture of 3 parts chalk (or limestone), and 1 part salt at the rate of 1% of the ration, if it contains 5% fish meal. If 10% is fed, no mineral is necessary.

Two experiments were conducted at Nappan to determine the value of additional minerals in a fish meal ration. The results of the first of these are given in Table 9, and the data indicate that the addition of 2% bone meal to the ration had no beneficial effect, either in rate of gain or quality of product. Fish meal was fed at the rate of 8% of the ration and gradually reduced to 4% during the final month before slaughter.

In the second experiment, ground limestone was fed at the rate of 0.4% up to 100 pounds live weight, then 0·3% to finish at 200 pounds. From this single test the addition of limestone showed an increase in average gains and a lower feed consumption per unit of gain. Fish meal was fed to both groups of hogs at the rate of 8% for the first period, reduced to 3% at finishing.

The addition of from 1 to 2% of a mineral supplement is recommended when fish meal forms only a part of the protein supplement in the ration.

The salt content of fish meal may vary greatly, and may be high if the meal is made from fish that have been salted to prevent spoilage. The effect of this salt, when the product is used for hog feeding, is discussed by Bomer (5), Honcamp (32), Korell (48) and Mayrhofer (61), who conclude that salt-rich fish meal (up to 20% in the case of Honcamp) is not injurious to growing pigs. Durrwaechter (19) reported slightly better results, although not so economical, with a low salt fish meal ration.

Summarizing the results reported by these investigators, it would appear that the salt content of fish meal is not of material consequence,

for swine feeding purposes, providing it is not sufficiently high to reduce the content of protein and of the other minerals below the average analyses given previously in this paper.

Vitamins

Blissett (3), Honcamp (32), Kik and McCollum (44), McFarlane *et al.* (60) and Woodman (103), discuss the value of fish meal as a source of vitamins A, B and D. It is generally agreed that the product is deficient in B, while it varies greatly in A and D, chiefly because of the variation in oil content.

Woodman's 1933 summary (103) suggests that since cereals, in most cases form a portion of the pigs ration, the vitamin requirements are adequately taken care of, and the supply in the fish meal portion is of minor importance.

Fats

The fat content of fish meal varies according to the raw material from which the meal is manufactured and according to the process of manufacture. High grade white-fish meal, manufactured from white fish, such as haddock, cod, etc. or from the trimmings of such fish left over from filleting, is low in fat, usually below 3%. Herring, mackerel and other oily fish, when used in fish meal manufacture, result in a product high in fat, usually ranging from 9 to over 20%. Some manufacturers extract this fat, leaving a dark fish meal of low fat content.

Much controversy existed and continues to exist on the relative values of these types of fish meal for livestock feed. Early in the history of the manufacture of fish meal, little care was taken as to the kind of raw material used in its manufacture. As a result, some meals were marketed made from whole oily fish, or containing a high percentage of entrails, and trouble with taint was immediately experienced. This led to the condemning of the use of fish meal for livestock feed, without qualification as to its source or quality.

Woodman (103) states that "herring meal" should not be used for any other purpose than for fertilizer, because of the lack of uniformity in the product and the danger from taint. Bomer (5, 6), reports feeding trials where herring meal gave superior gains to white-fish meal, but the carcass fat was tinged yellow from its use, and taint was noted in the liver and brains of hogs so fed, although no odor or taint could be detected in the ham and bacon. Korell (48) fed herring meal, both fresh and stored, containing up to 14.4% fat without harmful results and concludes that the quality of carcass and rate of gain are independent of the type of fish meal fed. Orr and his collaborators (68, 69, 70) report taint from feeding herring meal containing as low as 6.4% fat, but no taint could be detected when white fish meal, made from the bones, heads and flesh of white fish, was fed to any class of livestock. They definitely advise against the use of herring meal, because of the danger of taint. Crowther, (103B), emphasizes the safety with which white-fish meal may be used when employed in the correct amount in the rations of bacon hogs.

Davidson (7) reports that fat in fish meal depressed gains, and Durrwaechter (19) secured best results from a fish meal low in fat, while De Ruyter de Wildt (11) reports superior gains from fish meal containing up

to 9% fat when compared with the same meal from which the fat had been extracted. Kernot and Speer (43) secured higher gains from ether-extracted oily meal than from white-fish meal.

There is some evidence that the free fatty acid content of the fat in fish meal may be responsible for some difficulties experienced in feeding oily-fish meal. Moer (64), testing the keeping qualities of herring meal, secured best results when the meal was thoroughly dried before storage. He suggests that the free fatty acid content (normally 5% of the fat) is a good indicator of the quality of the meal. Some meals that showed decomposition in storage contained as high as 40% of the fat in the form of free fatty acids.

Few experiments have been conducted in Canada to determine the relative value of different types of fish meal manufactured in this country. Bailey (97A), reports the results of comparative trials conducted in 1935 and 1936 comparing white-fish meal with oily-fish meal. No significant difference was secured in rate of gain, but there was some difference of opinion in regard to the flavor of pork from hogs fed oily-fish meal.

The evidence presented above is only a very small portion of that available, showing the differences of opinion existing regarding the advisability of feeding herring or oily-fish meal. It is generally agreed by all experimenters that white-fish meal is a safe and satisfactory protein and mineral supplement.

Further experimental work is contemplated by the Experimental Farms in Canada, but until more data is available, the use of oily-fish meal as a livestock feed is only recommended in maintenance or growing rations.

FISH MEAL AS A PROTEIN SUPPLEMENT

A wealth of material has been published during the past 20 years on the value of fish meal when used to replace other animal or vegetable proteins in the ration of bacon hogs. The majority of these are comparisons with tankage or skim-milk. Time will not permit a detailed analysis of these, but reference will be made to a few representative experiments, in discussing the results of the Nappan trials.

Fish Meal Compared with Tankage

In 1923–24 the first comparative tests were made at Nappan with fish meal, tankage and skim-milk. The fish meal used was an imported product, containing 58.32% protein, 6.99% fat and 26.77% ash. The tankage was 60% protein. The best gains were secured in the tankage-fed groups. The fish meal gave somewhat lower gains than tankage, but was about equal to skim-milk in this regard. The tankage fed hogs, however, were shorter and thicker than those receiving the other supplements. This test showed that fish meal had a definite value as a protein supplement, and as the manufacture of this product was under way in Eastern Canada, further investigations seemed to be justified.

In 1924, a supply of fish meal, sold under the trade name of "Protan" was secured. This was of good quality, but was high in price, when compared with tankage.

Two experiments were conducted in 1925, one comparing "Protan" with skim-milk and tankage, the other with skim-milk only. In each test

an additional group of hogs was included that did not receive any protein supplement.

The results are given in Tables 1 and 2, and indicate that "Protan" was equal to skim-milk in rate of gain and that both were superior to tankage. The rate of feeding "Protan" (20% of the grain ration) was higher than necessary and accounts for a part of the increased cost per unit of gain when this supplement was used.

A supply of herring meal was secured in 1926, which while low in price, was also low in protein content (48%) and high in fat (14%). The results of a feeding trial, comparing this feed with tankage and skim-milk are given in Table 4. In this test, the fish meal proved to be superior to tankage and equal to skim-milk in rate of gain live weight, but somewhat higher in feed consumption per unit of gain. As in 1925, the fish meal was fed at the rate of 20% of the grain ration, and tankage, 8%.

In 1933 and 1934 two trials were conducted using white-fish meal in comparison with tankage. An additional lot was included that received the animal protein part of the ration from both tankage and fish meal in equal parts.

Tankage alone was fed at the rate of 10% gradually reduced to 5% during the finishing period, and fish meal alone 8%, reduced to 4%. This supplied equal amounts of protein to each lot, as the fish meal contained slightly more than 70% protein, and the tankage 60%.

The results, as given in Table 9, showed fish meal to be decidedly superior to tankage, with the combination of the two feeds in intermediate position. The fish meal fed hogs were superior in type and finish.

The results of these experiments would indicate that high grade fish meal is definitely superior to tankage as a protein and mineral supplement for bacon hogs. These results tend to substantiate those reported by other investigators. For example, Durrwaechter and Horst (18), Edwards 20), Evvard (21), Lunde *et al.* (53), Robison (73, 75), Skelley (82) and Wowra (95) all report results of feeding trials in which fish meal proved to be superior to tankage for hog feeding purposes. Kleberger and Horn (45), and Meyer (62) report that herring meal proved to be equal to tankage in experiments they conducted. De Ruyter de Wildt (9A) reports that pigs fed fish meal were more fleshy, better proportioned and produced a better quality of meat than those fed other supplements.

TABLE 1.—COMPARISON OF "PROTAN", TANKAGE AND SKIM-MILK. ONE TRIAL, 1925

Item		"Protan"	Tankage	Skim-milk	Check
Total hogs in test	No.	7	7	7	7
Average daily gain (107 days)	Lb.	1.13	1.10	1.14	.96
Feed cost per 100 lb. gain	$	12.22	9.85	9.72	10.49
Meal equivalent per 100 lb. gain	Lb.	472	425	430	458
Per cent "Select" bacon	%	86	57	43	29

TABLE 2.—COMPARISON OF "PROTAN" AND SKIM-MILK. ONE TRIAL, 1925

Item		"Protan"	Skim-milk	Check
Total hogs in test	No.	4	4	4
Average daily gain (172 days)	Lb.	1.08	1.04	.92
Feed cost per 100 lb. gain	$	10.30	8.47	8.60
Meal equivalent per 100 lb. gain	Lb.	407	389	393

TABLE 3.—COMPARISON OF SKIM-MILK AND FISH MEAL. ONE TRIAL, 1926

Item		Skim-milk	Fish meal	Check
Total hogs in test	No.	7	6	5
Average daily gain (140 days)	Lb.	1.01	1.26	.76
Feed cost per 100 lb. gain	$	7.50	9.19	8.21
Meal equivalent per 100 lb. gain	Lb.	380	399	418

TABLE 4.—COMPARISON OF TANKAGE, FISH MEAL AND SKIM-MILK—ONE TRIAL, 1926

Item	Tankage	Fish meal	Skim-milk	Check
Total hogs in test	5	5	5	4
Average daily gain (142 days)	1.07	1.24	1.23	1.14
Feed cost per 100 lb. gain	9.00	8.30	7.70	8.50
Meal equivalent per 100 lb. gain	408	410	371	409

TABLE 5.—COMPARISON OF SKIM-MILK AND FISH MEAL. AVERAGE OF FIVE TRIALS, 1927 TO 1931

Item		Skim-milk weaning to finish	Skim-milk to 3 months		
			Fish meal 3 months to finish	Fish meal 4 months to finish	Grain only after 3 months
Total hogs in test	No.	25	25	24	25
Average daily gain (143 days)	Lb.	1.06	1.04	1.04	.94
Feed cost per 100 pounds gain	$	7.67	7.96	7.96	8.40
Meal equivalent per 100 lb. gain	Lb.	398	403	400	437

FISH MEAL COMPARED WITH SKIM-MILK AND OTHER SUPPLEMENTS

Reference has already been made to several experiments conducted at Nappan, comparing fish meal and milk as well as tankage. A number of other direct comparisons have been conducted, the first in 1926, using herring meal as referred to in the previous section.

The results of this experiment are given in Table 3. Fish meal proved to be superior to milk in rate of gain, but the feed intake was slightly higher. The high rate of feeding (20% of the grain ration) increased the unit cost of gains over that of milk.

From 1928 to 1936, fourteen feeding trials were conducted comparing fish meal with skim-milk, using a total of 158 hogs. The average results are given in Table 7.

White-fish meal was used in all tests and proved to be practically equal to milk in rates of gain and feed consumed per unit of gain. The hogs fed fish meal were superior in type and finish. In several of the tests grading data was secured, 70% of the fish meal fed hogs grading "select bacon" as compared with 43% for those receiving milk.

From 1926 to 1931, five feeding trials were conducted, comparing milk alone, with milk as a starter followed by fish meal fed at various stages in the growing or finishing periods. The various combinations and the results ecured are given in Tables 5 and 6. The data would indicate that equally as good results might be expected from a fish meal ration fed after the pigs are 3 months of age as from skim-milk fed from weaning to finish. Here again the fish meal fed hogs were superior in type and finish, as shown by the grading results in Table 6.

The average results of 3 feeding trials conducted from 1930 to 1932 are presented in Table 8. Comparisons were made of skim-milk with fish meal fed at 2 rates from weaning to finish, 8% and 4% of the grain ration.

Skim-milk proved to be slightly superior to fish meal in rate of gain, but there was no significant difference in food intake. Comparing rates of feeding fish meal, 4% of the ration proved to be slightly more economical than did 8%.

In 1937, a comparison was made between fish meal and the protein supplement as used at the Advanced Registry Test Stations, for Swine. The results (Table 10) show that in this single test fish meal was slightly superior to the more complicated ration in economy of gain and quality of product.

OTHER EXPERIMENTS WITH FISH MEAL

In addition to the experiments reported above, several lots of hogs have been fed since 1934 with the object in view of securing data on the value of potatoes, when supplemented with fish meal, for bacon hogs.

Table 11 gives the results secured from 3 trials comparing potatoes with a grain ration fish meal being used as the protein supplement for both lots. This data indicates that cull potatoes, supplemented with white-fish meal, may be marketed to advantage through the bacon hog and that the hogs so fed should grade from 50 to 60% top grade carcasses.

TABLE 6.—COMPARISON OF SKIM-MILK AND FISH MEAL. AVERAGE OF THREE TRIALS, 1926 AND 1927

Item		Skim-milk weaning to finish	Skim-milk to 3 months				Skim-milk to 4 months. Then grain only
			Fish meal 3 months to finish	Fish meal 4 months to finish	Fish meal 5 months to finish	Grain only after 3 months	
Total hogs in test	No.	15	15	15	15	15	15
Average No. days on test	Dy.	152	152	152	164	164	164
Average daily gain	Lb.	1.00	.98	.99	.91	.85	.83
Feed cost per 100 lb. gain	$	8.81	8.95	8.82	9.21	9.56	9.71
Meal equivalent per 100 lb. gain	Lb.	421	423	417	439	457	465
Per cent "Select" bacon	%	73	87	60	40	33	47

TABLE 7.—FISH MEAL *versus* SKIM-MILK. AVERAGE 14 TRIALS, 1928-1936

Item		Weaning to finish	
		Fish meal	Skim-milk
Total hogs in test	No.	80	78
Average daily gain (127 days)	Lb.	1.20	1.24
Feed cost per 100 lb. gain	$	6.28	6.03
Meal equivalent per 100 lb. gain	Lb.	370	372
Per cent "Select" bacon (60 hogs graded)	%	70	43

TABLE 8.—SKIM-MILK *versus* FISH MEAL. AVERAGE OF 3 TRIALS, 1930 TO 1932

Item		Skim-milk weaning to finish	Fish meal 8% of grain ration weaning to finish	Fish meal 4% of grain ration weaning to finish	Grain ration only
Total hogs in test	No.	17	18	18	17
Average daily gain (124 days)	Lb.	1.23	1.15	1.12	.95
Feed cost per 100 lb. gain	$	4.68	4.94	4.65	4.91
Meal equivalent per 100 lb. gain	Lb.	350	354	351	395

TABLE 9.—TANKAGE AND FISH MEAL COMPARISONS. AVERAGE OF 3 TRIALS, 1933 AND 1934

Item		Tankage	Fish meal	Fish meal plus bone meal	Tankage plus fish meal
Total hogs in test	No.	17	18	18	18
Average daily gain (129 days)	Lb.	1.05	1.22	1.20	1.17
Feed cost per 100 lb. gain	$	4.71	4.13	4.30	4.34
Meal equivalent per 100 lb. gain	Lb.	363	328	336	341
Per cent "Select" bacon (44 hogs graded)	%	36	55	36	55

TABLE 10.—COMPARISON OF MIXED PROTEIN SUPPLEMENT AND FISH MEAL. ONE TRIAL, 1937

Item		Swine feeding station supplement	Fish meal	Fish meal plus limestone
Total hogs in test	No.	5	5	5
Average No. days on test	Dys.	125	125	120
Average daily gain	Lb.	1.37	1.37	1.44
Feed cost per 100 lb. gain	$	5.60	5.37	5.17
Meal equivalent per 100 lb. gain	Lb.	358	349	330
Per cent "Select" bacon	%	0	40	40

TABLE 11.—GRAIN *versus* POTATOES WITH FISH MEAL. AVERAGE 3 TRIALS, 1934–1936

Item		Grain ration plus fish meal	Potatoes plus fish meal
Total hogs in test	No.	20	15
Average No. days on test	Dy.	152	165
Average daily gain	Lb.	1.19	1.11
Feed cost per 100 lb. gain	$	5.54	4.11
Meal equivalent per 100 lb. gain	Lb.	386	341
Per cent "Select" bacon	%	56	67

DISCUSSION

The results of the various experiments conducted at Nappan demonstrate quite conclusively that white-fish meal compares very favourably with skim-milk and other supplements as a source of protein for feeding bacon hogs. A survey of the literature on this subject would tend to substantiate the results secured at Nappan, although a great variation occurs in the data secured from various experiments.

Bunger (6A, 6B) found fish meal to be superior to skim-milk or mixed protein supplements. Frolick and Luthge (30) and Hostetler (34) on the other hand, secured best results with mixed supplements when compared with fish meal alone. Stahl (86, 88A), secured equally as good results with fish meal as with milk or meat meal. Wowra (94) secured better results from either cod meal or herring meal than from soya meal and dried yeast, while the University of Reading (99) found no significant difference in the efficiency of meat meal, fish meal or soya meal. The Iowa Experiment Station (108) found menhaden, haddock, and white-fish meal all superior to tankage, the least efficient of the three being white-fish meal. Bailey (97A) reports that fish meal seems to be superior to skim-milk when potatoes are included in the ration.

While these references are but a few of the many that could be cited, they do, nevertheless, form a cross-section of the literature on the subject and indicate the variability of the results secured from widely separated experimenters. This variability can be partially explained, at least, by

the great variation found in the quality of fish meal from different sources, and also in the breed and strain of hogs used. Considerable variation occurs in fish meal from any one source as has been found at Nappan, where samples of fish meal from one factory have varied nearly 10% in protein content, and 6% in ash. Davidson (7), concludes that the value of fish meal is associated with the protein content, and also with the amount and proportion of mineral constituents.

The fish meal used at Nappan (with the exceptions noted above) has been secured almost entirely from one source. This, no doubt, has a direct bearing on the uniformity of the results obtained from year to year.

The new experiments contemplated, comparing meals from various sources, should indicate the general quality of the fish meal produced in the Maritimes as a whole.

The bibliography included with this report includes several fairly complete discussions on the value of fish meal as a livestock food. Chief among these are by Honcamp (32), a rather extensive survey of the work in Germany, and Woodman (103) who summarizes the work in Great Britain and elsewhere in a very concise but valuable report. The writer has not had an opportunity of reviewing the second edition of Woodman's bulletin, but it is undoubtedly equal, if not superior, to the 1933 edition.

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J. I. Nelson, who has been directly responsible for the care of the swine herd at Nappan for over 16 years, has aided greatly in the conducting of the many feeding trials, through his close attention to detail, which is so essential in obtaining accurate data.

APPENDIX

Rations

The basal rations used in the experiments conducted at Nappan varied from year to year. From 1925 to 1928 they were made up chiefly of barley, oats and middlings, and from 1929 to 1931, oats, barley, shorts, bran, linseed oil meal, bone char and salt; with the exception of one experiment, where corn meal replaced part of the barley. From 1932 to 1934 the basal mixture was oats, barley, middlings, shorts and bone meal, (or bone char), while starting in 1935 the same basal ration as is used at the Advance Registry Test Station for Swine was adopted, namely, barley, oats and wheat in the ratio of 50, 30, 20 until the pigs are 100 pounds live weight, then 60, 10, 30 for the finishing period, or until the average live weight is 200 to 210 pounds.

In the potato-fish meal tests, the pigs received oats plus 8% of fish meal, and potatoes, ½ pound per pound of grain, gradually increased to 1½ pounds, until the pigs were 100 to 110 pounds live weight. The oats were then removed from the ration and the pigs finished on potatoes and fish meal fed in the ratio of 20 : 1 by weight.

Skim-milk was generally fed at the rate of 1½ to 2 pounds per pound of grain. This was gradually reduced to 1 pound during the finishing period.

Methods

In all cases, where possible, littermates or pigs closely related were used in comparative lots. Pigs were weaned at 6 to 8 weeks of age and placed on test at 8 to 10 weeks. They were selected for uniformity in age, sex and weight and group fed. As a rule, feeding was done three times daily until the pigs were 100 to 125 pounds in weight, then twice daily to finish.

All pigs used were of Yorkshire breeding and marketing was done as near to the standard weights (200 to 210 pounds) as possible. While the measure of any feed formerly included the rate of gain, feed requirements, and feed cost per unit gain, latterly the further question as to type of carcass produced has been considered. In many cases, particularly since 1934, the hogs have been scored on the slaughter test, similar to the scoring under the Advanced Registry Policy, and the statements made regarding quality of carcass are based, whenever possible, on the results of this study.

In compiling the data presented in the following tables, it was found that in some trials, particularly previous to 1934, green feed in some form was used. In order that comparisons might be made on the basis of feed intake per unit of gain, arbitrary values were placed on the various feeds used, and in this way direct comparisons are possible between rations. The factors used were as follows:—

Class of feed	Amount to equal 100 pounds meal, lb.
Dry meal ration	100
Roots and other green feed	500
Potatoes	450
Skim-milk	1000

These amounts, while only estimates, are based on the results secured from experiments conducted at Nappan, together with various estimates obtained from Morrison's "Feed and Feeding" and other references.

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151. Value of Shrimp Meal. John Ruel Manning. (Mem. S 328.)
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CANADIAN SOCIETY OF ANIMAL PRODUCTION

(Eastern Section)

The Annual Meeting of the Canadian Society of Animal Production (Eastern Section), an affiliated body of the Canadian Society of Technical Agriculturists, was held at the Central Experimental Farm, Ottawa, Canada, on June 28th and June 29th, thus coinciding with the summer meetings of the American Association for the Advancement of Science. Two sessions were held, the former including business, reports, and addresses while the latter was in the nature of a symposium on *The Progress of Swine Improvement in Canada*. The programme of the second session, which included six papers, was of particular interest. The policy of the Dominion Department of Agriculture with regard to the Advanced Registration of purebred swine was outlined, and the several papers included the results of its operation at different centres, relating to progress in breeding, nutritional, carcass evaluation, and market quality studies. These papers are presented in this issue of *Scientific Agriculture*.

The officers of the Society elected for the year 1938–39 are as follows:—

President: R. G. Knox, Ontario Agricultural College, Guelph, Ont.

Vice-President: L. W. Pearsall, Production Service, Department of Agriculture, Ottawa, Ont.

Ontario Director: F. N. Marcellus, Ontario Agricultural College, Guelph, Ont.

Quebec Director: J. R. Pelletier, Experimental Station, Ste. Anne de la Pocatiere, Que.

Maritime Director: S. A. Hilton, Experimental Farm, Nappan, N.S.

Secretary-Treasurer: C. D. MacKenzie, Experimental Farm, Ottawa, Ont.

ADVANCED REGISTRY FOR PURE BRED SWINE[1]

A. W. Peterson[2]

Production Service, Department of Agriculture, Ottawa, Ontario.

In looking back over the record of the development of the swine Advanced Registry program, it is interesting to note that the first public announcement of this policy was made before the Eastern Society of Animal Production at its first annual meeting held in Quebec City in 1928. Mr. L. C. McOuat, who at that time was Bacon Specialist with the Dominion Department of Agriculture, presented an outline of the Advanced Registry Policy as developed and recommended by the Joint Swine Committee and approved by the Department of Agriculture. It seems fitting that just ten years later the opportunity is afforded to report before the Society the record of development. The purpose of my remarks is to bring up to date the history and development of this work and to create a background for those who are to follow on this program, and who will deal in detail with the principle involved and the results obtained.

Although the past ten years have brought about many changes with respect to the methods of administration and operation, the three cardinal principles, as laid down ten years ago, still remain. These principles are as follows:

1. The testing of pure bred swine for their commercial value.
2. The development of a pedigree based on performance.
3. Providing the swine breeder with a service parallel to that provided the breeder of dairy cattle and the poultry breeder through the agency of the Record of Performance for Dairy Cattle and Laying Hens.

Although the example of the pig testing work in Scandinavian countries gave a lead, the nature of our country and distance demanded the development of a policy to suit Canadian conditions. During the first stages, the whole project was purely experimental in that sows maintained at the Dominion Experimental Farms were the only ones tested. With this experience, a basis of scoring, or valuing the sows, through the performance of their progeny was developed. The next step was the enlargement of the scope of the policy to include certain other institutional farms across Canada, and in 1930, with the more confidence in the value of the standards laid down, the service was made available to all breeders of pure bred swine in Canada who regularly maintain herds of not less than three sows and a herd boar.

One of the first things that had to be established before any records, such as were contemplated, could be authentic was absolute and unquestionable identification of the sow entered for test and of all of her progeny. No satisfactory method existed and one had to be developed. Tattooing offered the best possibilities, and after trial with a variety of inks, methods and equipment, it was adopted and has since become not only the one recognized identification for tested pigs and their progeny, but is now com-

[1] An address delivered before the Ninth Annual General Meeting of the Canadian Society of Animal Production (Eastern Section) at the Central Experimental Farm, Ottawa, Ontario, on June 29, 1938.

[2] Chief, Live Stock and Poultry Division, Production Service, and Chairman of the Canadian Advanced Registry Board for Swine.

pulsory for the registration of all white purebred hogs in Canada. The commercially important factors which were established as essential and which could be tested were the production of the sow, the rate of gain, and the carcass value of the progeny. As the export commodity was the final product required, Wiltshire sides were at first made in all cases, but the variation, due to the human factor, in such a process was found to be too great. Hog carcasses were studied in relation to the kind of Wiltshire produced and it was found that certain measurements of the uncut cold carcass could be taken and certain cuts could be made which would reliably indicate the suitability of the carcass for Wiltshire purposes without actually making the Wiltshire itself. Figure 1 shows the points at which the various cuts and measurements were and are still taken at F. D, C, G, and H.

In addition to cutting the carcass in order to determine the balance of ham and shoulder to middle, measurements are taken of back fat, and the belly is scored for quality.

Table 1 shows the factors used in scoring the carcass and illustrates also the method and the degree of deduction for faults from the standard. This is the method used in scoring carcasses up to the present. In future, however, it is intended to apply a new basis of scoring which has been developed from the experience gained and from the data collected on thousands of carcasses handled during the past 10 years. This new basis of scoring differs from that used until now in that another factor is introduced, the eye of lean, Figure 2.

TABLE 1.—ADVANCED REGISTRY FOR SWINE SCORING CHART

Factors used in scoring	Length of carcass	Back fat		Balance of side			Belly grade
		Thickness	Evenness	Ham	Middle	Shoulder	
Prefect score	24	12	12	9	9	9	25
Standard required for perfect score	30½ inches or more	Maximum 2 inches Minimum 1 inch	Not more than ¾" difference between Maximum and Minimum	Not less than 25%	Not less than 50%	Not more than 25% (Of total weight of three cuts)	Must grade "Excellent" (E)
Points deducted for each fault from standard	30–30⅜".1 29½–29⅝".2 under 29½.6	2	2	1	1	1 (For each percentage)	Good (G)...2 Fair (F)....4 Poor (P)....6

NOTE.—Two points from total score are deducted for each carcass weighing over 160 pounds.

This factor is measurable, and under packing house conditions it has been found that a figure represented by the product of the distances between AB and CD adequately represents the actual area as determined by the use of the planimeter. To measure the "eye of lean" the carcass is cut at E, Figure 1. The new basis of scoring differs in another instance in that different standards are provided for each 10-pound weight range in

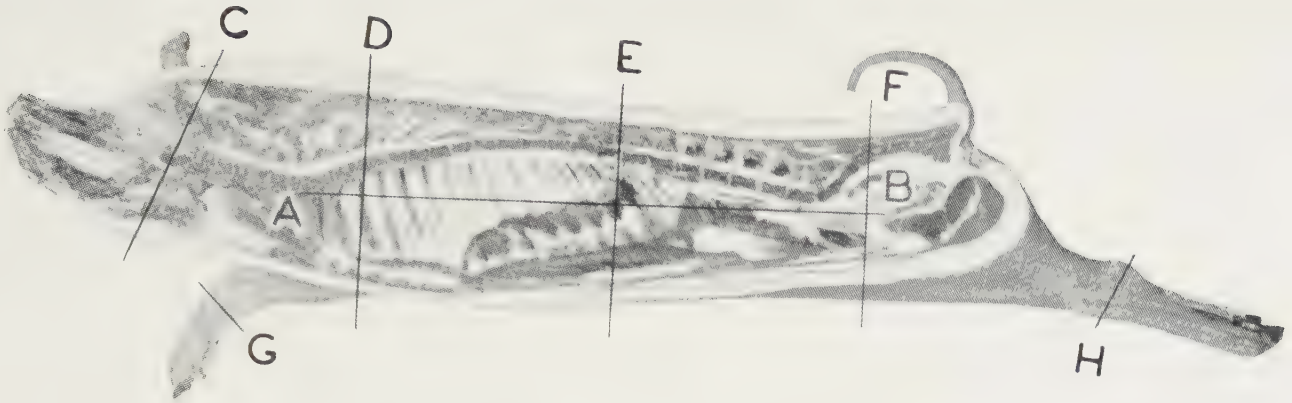

FIGURE 1. Full side of hog carcass showing points at which cuts are made and measurements taken.

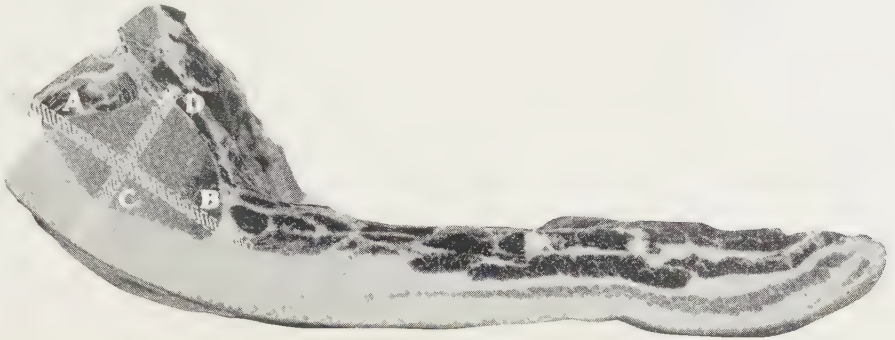

FIGURE 2. Cross section of side showing the points between which the eye of lean is measured.

the carcass, which means that a carcass of 135 lbs. would not require as thick a measurement of back fat, nor as much length, as a carcass of 155 lbs.

In developing this scoring basis, the work of Hammond[3], School of Agriculture, Cambridge, has been an inspiration and in almost every case our own findings and those of Hammond are in agreement.

In the year 1933, the Canadian Swine Breeders' Association while in session at Winnipeg passed a resolution endorsing Advanced Registry, and as a result of this action the Canadian Record for Swine, published by the Canadian Swine Breeders' Association contains the names and Advanced Registry numbers and scores of all sows which qualify during each year. Furthermore, all pedigree certificates carry not only the Advanced Registry number of all qualified animals whose names appear on the certificates, but also the score of the sows for which the certificate is issued.

Although the original intention of Advanced Registry did not include the establishment of test stations, as time went on it became evident that testing the nominated litter groups on the premises of the farmer was unsatisfactory for three reasons: (1) Many farmers with large herds, particularly in Western Canada, had not the facilities to maintain small groups of pigs of varying ages in separate pens and give them the necessary attention for a comparative test during different seasons of the year; (2) Pigs were fed on a variety of feeds and under a variety of methods; (3) The home feeding plan did not permit of feed consumption records.

In 1934, after a great deal of discussion and study, it was decided to embark on the policy of station testing. At first, existing piggeries were utilized. The owners of the piggeries used became attendants and they were paid on the basis of the number of sows tested. The unsuitability of such buildings for the purpose, and the lack of them, suitably located for testing, necessitated construction of piggeries by the Department of Agriculture. Two buildings were constructed in 1937, one at Saskatoon, and one at Edmonton. The necessary care was exercised in construction to provide for insulation, ventilation, lighting and sufficient artificial heat to maintain a temperature of about 45 degrees during the winter months so as to insure litter groups an equal opportunity in winter as in summer.

These buildings have fully justified the objectives and it is the intention to proceed with the building program until sufficient test station space is available to accommodate all sows offered for test. At the present time, sufficient space exists in the Maritime Provinces and in Manitoba to accommodate all of the groups offered for test. In the other two Western provinces, sufficient accommodation is available for half of the sows and in Ontario for about one-third.

The Dominion Department of Agriculture is responsible for the administration and for the financial support of the Advanced Registry Policy, and while officers of the Production Service operate and direct the work, a body known as the Advanced Registry Board, which is composed of representation from the Canadian Swine Breeders' Association, Eastern and Western Canada Live Stock Unions, Industrial and Development Council of Canadian Meat Packers, Canadian National Live Stock Records, Dominion Experimental Farms and the Markets Service, acts in an advisory

[3] A method for judging pork and bacon carcasses. H. R. Davidson, John Hammond, Jos. B. Swain, and Nevill L. Wright. Pig Breeders' Annual, Vol. 16, 1936–37.

capacity to the Department, and during regular annual meetings considers and recommends suggested changes and amendments as required. Attached to the Board are several committees, such as the Feed Committee, Building Committee, Sanitation Committee, etc. The Feed Committee has been particularly effective, and during the past three years has conducted experimental feeding tests at the different experimental institutions across Canada, resulting in the development of the feed mixtures now used at all Test Stations.

Simultaneously with the decision to develop the station testing plan, provincial test station committees were organized, the membership of which is appointed by the Provincial Deputy Ministers of Agriculture. The purpose of these committees is to look after the matter of local management of the test stations, and to be responsible for the hiring of the attendants, the purchasing of feeds, and the basis upon which pigs are taken into the stations. While these committees are charged with matters of local management, the rules which have been laid down with respect to rations, etc., are entirely uniform at all stations in Canada.

The present status of swine testing in Canada can be indicated quite clearly by a few figures. Slightly over 500 pure bred breeders have enrolled one or more animals for test; 425 of this 500 are actively engaged in testing. When one considers that the 1937 membership of the Canadian Swine Breeders' Association was 935, it can be safely surmised that at least half of the membership are regularly testing their pigs for Advanced Registration. It should be remembered that of the 935 members of the Canadian Association, a good many of them would not have herds of sufficiently large size to qualify for entry under the Advanced Registry Policy.

To date 1185 sows and 145 boars have been qualified. Breeders appear to feel that testing is essential to the development of their business and in making sales of breeding stock. Some of the Class "A" Fairs already required Advanced Registry credentials as a requirement for entry in the swine classes and the Ontario breeders by resolution have requested that Advanced Registry credentials become a factor in some of the larger fairs.

The Advanced Registry Board and the Department have continued over the past ten years to explore and study the latest findings in connection with the feeding and the breeding of swine and to apply such findings to pig breeding through the machinery of Advanced Registry. The data collected from the thousands of pigs killed under the test have been carefully analyzed with the result that changes in methods and changes in technique have been found from time to time to be advisable. Perfection, while of course not yet achieved, will be the continued objective of those whose responsibility it is to conduct the testing programme. The knowledge of the best authorities to be found in Canada has been pooled and will continue to be pooled to that end.

TEST STATION OPERATION[1]

R. G. KNOX[2]

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Your attention has been called to the Administration and operation of the Advanced Registry for Swine Policy, and it has been suggested that my responsibility to this programme should have to do with the principles relating to Advanced Registry Test Stations, methods, rations, feeding, etc.

When this policy was first put into operation it was deemed advisable to afford our breeders of purebred swine opportunity to decide for themselves as to the worthiness of the undertaking, and with this fact in view they were permitted to feed the progeny of their sows at home, provided they did so according to regulations. As time went on it was felt by those responsible that further imitation of the principles common to pig testing work in other bacon producing countries was warranted, and as a consequence Test Stations were established in the provinces where it was believed that the undertaking would be supported. At the beginning it was a matter of making use of all facilities that were readily available. In some cases barns owned by institutions were placed at the disposal of those responsible for the project. In other provinces properties were leased and the buildings employed to temporarily satisfy the requirements of a Test Station. These different stations were looked upon as somewhat of a temporary arrangement which would provide information relative to a satisfactory type of equipment which might serve in the way of housing pigs in a similar manner across the country.

Thanks to the co-operation of many groups of people who have been sympathetic to this undertaking, there is in existence a Federal policy which will ultimately enable the establishment of Test Stations of similar construction in all of the provinces of the Dominion.

Feed Committee

It is unnecessary to point out the importance of the ability of a pig to make economic use of his feed. In order to place a reliable nutrition yardstick on the hogs which would go into these Stations it was necessary to utilize all available information relative to swine nutrition. To accomplish this a group of men from different institutions in Canada were brought together by Mr. A. W. Peterson for the purpose of deciding upon a ration which should be suitable for the determination of the ability of a pig to utilize his feed to best advantage, not only from the standpoint of growth, but from the standpoint of a carcass that would satisfy the requirements of the British market. This group of workers, eventually named the Feed Committee for the Advanced Registry for Swine Policy, happily recognized the considerable variation of opinion as to desirable hog rations, and after serious consideration drafted formulae for rations to be used in the Test Stations in operation. I wish to point out here that apart from any contribution which the committee may have made to the development of a more uniform type of breeding stock in this country, that a very con-

[1] An address delivered before the Ninth Annual General Meeting of the Canadian Society of Animal Production (Eastern Section) at the Central Experimental Farm, Ottawa, Ontario, on June 29, 1938.

[2] Professor of Animal Husbandry.

siderable amount of credit is due Mr. Peterson because of the part that he played in bringing about the realization that there was not a unanimity of opinion as to how our Canadian hogs should be fed. I offer this commendation in full recognition of the great variation in the topography and productivity of the country, and at the same time repeat that the meeting from time to time of this group of workers has tended in a very definite way to stabilize the fundamental principles relative to hog nutrition. This Feed Committee has been responsible for an extensive programme of investigational work. Groups of hogs have been subjected to different rations and the carcasses from these groups have been graded according to the Advanced Registry slaughter test. As a result of this series of investigations the rations used at our Test Stations have been modified considerably from time to time. It is true that in the opinion of some workers, economy has not been a primary factor. Nevertheless an objective has always been kept in mind, namely, that the rations are so formulated as to permit of imitation. The Feed Committee realizes that climatic and feed conditions across the Dominion are not by any means identical, and from an economical standpoint there should be opportunity for modification in the case of the practical feeder.

It should be readily appreciated that dairy by-products are not available in all sections of this country, as well as the fact that our grains must be supplemented with protein in some form. The ambition of the Feed Committee has been to discover a combination of other by-products which might replace dairy by-products as a satisfactory source of protein in swine nutrition.

The mineral-vitamin content of a swine ration has also been given consideration. The protein-mineral supplement used at the various stations during 1937–38 was as follows:

Tankage	50
Fish Meal	15
Linseed Oilmeal	25
Salt	5
Limestone or Bone Meal	5

It has been recommended that cod liver oil be fed during the growing period at the rate of 15 cc. per pig per day.

As a result of experimentation the following two basal rations were recommended, either one of which could be used:

No. 1			*No. 2*		
—	1st Period	2nd Period	—	1st Period	2nd Period
Barley	50	60	Barley	20	30
Wheat	20	30	Wheat	50	60
Oats	30	10	Oats	30	10

The above mixture constitutes 85% of the ration in the first period with the addition of 15% of the protein supplement, and 94% in the second period with 6% of the supplement.

Naturally all of the feeds used in these rations must be of a standard quality. Again may I repeat that it does not necessarily follow that these rations will be used indefinitely, for as fresh information is made available it is within the province of the Committee to recommend any changes that they may see fit.

Measurement of Feed Intake

Nominated hogs are delivered to the Test Station when they are between 60 and 65 days of age, and to avoid any undesirable effect arising from change of feed or environment they are fed the station ration for 5 days before going on test at 70 days of age. The feeding period is divided into two stages, *viz.*: "growing" from 70 days of age until they weigh approximately 110 pounds, and "finishing" from 110 pounds until ready for market. During the entire test a semi-monthly weighing is made of each pig and at the same time the amount of feed consumed by the group during the 2-week period is recorded. By this means there is made available a picture of response to feed during both the growing and finishing periods, or in other words, it is possible to follow the history of a group of hogs with a considerable amount of accuracy while they are at the Test Station. This information in itself should be of importance to the breeder and in time to come should be of value in selective breeding.

Personal Factor

Experience to date has shown that there is a personal factor in Test Station operations which requires a considerable amount of close observation. There are pig feeders and pig feeders. What one man may consider full feeding is not so in the opinion of another, and as a result of this fact those in charge of the various stations have found it necessary to arrange for frequent inspection of the method of operation of stations. In another part of the programme I understand that information relative to the effect of different methods of feeding will be given, and at this time I must content myself with offering a suggestion arising out of experience, namely, that an efficient pig feeder in a testing station or elsewhere is a man who naturally knows live stock, particularly hogs, has a keen power of observation, is interested and accurate in his work, is aware of his responsibilities, and is amenable to suggestion.

Co-operation of Breeders

The success of a Test Station depends in no small way upon the co-operation of the breeders of purebred swine who are forwarding pigs to be tested. While the pigs that are being forwarded to the Station are inspected and identified by a representative of the Dominion Department of Agriculture when they are about six weeks old, there remains plenty of opportunity in the interim between inspection and delivery to the Station for the invasion of disease or the occurrence of some other misfortune which might retard the growth and development of the pig. It has been fairly clearly demonstrated that in order to qualify with reference to maturity the four pigs should weigh between 130 and 140 pounds with a maximum spread of 10 pounds when they are 70 days of age. It is common knowledge that there have been exceptions to this standard, when the pigs have qualified with respect to this factor. Doubtless genetical characters have

been responsible for this exception. Then again there is the question of health as influenced by internal parasites. It is sometimes discouraging to learn of the indifference of some of our breeders of purebred swine in this respect, because it is a recognized fact that a parasite-infested pig is not physically able to manifest his inherited ability to utilize feed.

It is anticipated that when all of the Test Stations in the country are constructed on a similar plan the health factor during the period of feeding will not be of such consequence as it is at the present time, or in other words, that this factor of variation will have been eliminated to a considerable extent and consequently those who are responsible for the administration of the policy will be protected to a greater extent than they are at the present time. Furthermore, fairer comparison of pigs from different areas of the Dominion will be possible.

Conclusion

In conclusion may I call to your attention that the purpose of the Advanced Registry Test Station is to provide a means of measuring the feeding qualities of the purebred swine in this country. The purpose is not necessarily to condemn the breeding stock which does not qualify, but to show the breeder how and where his hogs are deficient, and to afford him an opportunity of learning where hogs of suitable type and other characters are available. The Test Station should be the means of ascertaining the feeding qualities of these hogs, and since the rations are uniform across the country, the impersonal yardstick of carcass measurement is of considerably greater value because of the uniform method of feeding. At the outset it was intimated that the operation of our Stations is to some extent an imitation of the principles adopted in other countries where pig testing is in operation. The people responsible for the administration of this policy in Canada have developed it slowly and I believe wisely, and it is hoped that at some future date it will be possible to state within a reasonable latitude the weight that a pig should be at a given age and how much feed he should consume per day at that age. This may sound rather dogmatic, but it is my humble opinion that if even an approach to this standard were made the breeders of purebred swine in Canada would be in a position to offer to our commercial breeders decidedly more uniform breeding stock.

RESULTS OF STATION TESTING IN CANADA[1]

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Station Testing

Station feeding of pigs for Advanced Registry test was started in 1934 when four Advanced Registry Test Stations with a capacity of 86 pens were established. Table 1 gives a summary of the sows tested both at stations and at home each year since 1934.

Table 1.

Year	No. Stations	At Stations			At Home		Total	
		No.	Per cent qualified	Feed consumed	No.	Per cent qualified	No.	Per cent qualified
1934	4	46	39.1	461	178	57.3	224	53.5
Jan. 1935–36	5	185	44.3	463	206	54.9	391	49.9
* 1936–37	7	190	54.7	465	233	54.9	423	54.8
* 1937–38	7	270	50.0	466	203	64.5	473	56.2

* Fiscal year.

The present capacity of 7 stations is 158 pens, of which 60 pens are in two buildings constructed by the Department of Agriculture during 1937 at Edmonton and Saskatoon, and which were ready for occupancy in July of that year. It will be noted that 1937–38 was the first year in which more sows were tested at stations than at home. With the program of construction now under way station testing should be possible for all groups within the next two or three years.

The estimated net cost per group tested under station testing is as follows:

1935–36 — $18.61 1936–37 — $23.68 1937–38 — $24.59

The net cost is affected to a considerable extent by the sale price of pigs and the cost of feed. As no variation is permitted in the test station feed mixture, its cost may at times be out of line with that of commercial mixtures in which substitution of satisfactory lower priced ingredients is possible.

Effect of Heating and Ventilation

The main reason for constructing piggeries in Western Canada was the difficulty of obtaining satisfactory buildings of sufficient capacity and satisfactory location to test the pigs offered. There was also an opinion which became stronger with more experience in station testing that stricter control of the environmental conditions, particularly with regard to temperatures, was of very great importance in providing a comparable

[1] Paper delivered before the Ninth Annual General Meeting of the Canadian Society of Animal Production (Eastern Section) at the Central Experimental Farm, Ottawa, Ontario, on June 29, 1938.

[2] Live Stock Production Assistant.

test in all seasons. Studies were therefore made of insulation, heating, and ventilation with the idea of including these features in any piggeries constructed by the Department. The two Stations constructed in Western Canada in 1937 are well insulated and equipped with hot air heating and forced ventilation. By use of this equipment, it was found possible to control temperatures and humidity with considerable success, as shown by Table 2. More difficulty was experienced in controlling both temperatures and humidity at Saskatoon than Edmonton, despite the fact that a ventilating shaft was installed as a foul air outlet at the Saskatoon piggery in addition to the regular equipment. Five tons of coal were used at Saskatoon and 11·7 at Edmonton, which indicates a more frequent change of air at Edmonton than Saskatoon. This is probably the explanation of the lower humidity maintained at Edmonton. Recently the speed of the fan at Saskatoon was increased to make more frequent changes of air possible. The operator of each Station keeps a log of temperatures, humidity, fires, and outlet and inlet openings as a guide in controlling conditions, a copy being forwarded to headquarters as a check on conditions maintained.

TABLE 2

	Temperatures		Humidity	
	Winter	June	Winter	June
Saskatoon	40–50°	50–60°	80–90°	80–90°
Edmonton	45–50°	60–70°	65–70°	55–60°

With only one year's experience with heated and ventilated piggeries, it is impossible to arrive at any definite conclusions as to the effect of controlled conditions on the groups tested. It can be stated, however, that very little trouble was experienced with sick pigs at these two Stations during the winter. Maturity indices were better at these two Stations for the pigs arriving from August to December than those arriving earlier. There was only one failure for maturity index in 39 litters admitted during these months. In the case of two Stations, neither of which is air conditioned, although one is heated by means of a stove, there have been more failures for maturity index in the litters arriving during the fall and winter months than at other times. All such failures cannot be attributed to conditions at the Stations as unfavourable weather probably affects the young pigs previous to their arrival at Stations, but the differences found are, we believe, an indication of the need for air conditioned piggeries.

One of the main reasons for adopting station testing was to standardize environment, rations fed, and marketing of pigs so as to provide the truest possible indication of the inherited qualities of the animals tested. Means adopted for providing standardization have already been outlined. In applying standardization, however, some difficulties were met, in addition to the housing problem already mentioned. Some of the minor difficulties have been solved as they appeared, but two main problems remain for which a completely satisfactory solution has not yet been found. First, it has not been possible to evolve a completely satisfactory and clear-cut method of judging Station operation, and second, it has not been possible to eliminate the personal element entirely from station management.

METHODS OF JUDGING STATION OPERATION

The following methods are used in judging whether the operation of any particular Station is satisfactory:

1. By comparing carcass scores and feed consumption of the different Stations.

By comparing the scores, particularly the maturity indices of groups fed at different Stations, some idea can be gained of the relative efficiency of any particular Station, especially if the comparisons include a reasonable number of groups in each case. There is some evidence, however, that there are differences of characteristics in pig population between districts; differences between Stations may be a reflection of these local peculiarities, and consequently too much reliance cannot be placed on differences between Stations as a measure of Station efficiency. Any differences found may be due to district differences. The chief usefulness of this method is as an indication of the need for a close check of operation.

2. By the finish of the carcasses marketed.

One of the factors scored under Advanced Registry is back fat and one of the objects at Test Stations is to have pigs properly finished at 200 to 210 pounds. Consequently, if the proportion of unfinished carcasses increases at any particular Station, it is a possible indication that something is wrong with the methods of feeding or the feed and an inquiry is made to determine if the Station management is at fault. It is believed that finish as related to the type of pig may be affected by factors which are not under the control of the operator, consequently this method can only be used as an indication of the need of checking operation.

3. By comparison between home and Station feeding results.

Due to the fact that there is insufficient Station capacity in some provinces, it is still possible to compare scores between groups fed at Stations with scores of groups fed at home. This method provides an indication of the efficiency of the management of the feeding Station. Its use is limited and its fairness open to question for the following reasons:

(a) All Station groups except those eliminated by death complete a carcass test, whereas it is estimated that only from 50 to 60% of the groups nominated for home feeding are actually forwarded for slaughter test and scoring. Presumably most of those forwarded have a reasonable chance of passing *maturity index* and, depending on the skill and experience of the breeder, a fair chance of yielding suitable carcasses. The comparison is therefore somewhat unfair to Stations. Further the breeder has 5 pigs from which to select the 4 for shipment for slaughter test. At Stations the 4 pigs forwarded for feeding are the ones scored.

(b) If the methods of feeding and feeds have any effect on the carcass, and there is some evidence that they have, a skilful feeder who is free to use any feeds he wishes and with the personal attention possible under home feeding conditions, has a much better chance of affecting the carcasses than has the operator of a Station who is definitely limited in the feeds that he may use and who is expected to treat all groups alike.

(c) In four provinces practically all groups for test are consigned to Stations and therefore no comparisons are available.

The following comparisons between average Station and home fed scores for 1937–38 for the provinces in which a reasonable number of tests were conducted at home are an indication of how closely Station scores are to home scores despite the advantages under home feeding:

TABLE 3

—	Home			Station		
	No. tests	Average maturity index score	Average slaughter test score	No. tests	Average maturity index score	Average slaughter test score
Ontario	110	105	77.5	75	100.9	77.2
Quebec	37	109	74	44	105	76.9
Saskatchewan	37	105.6	81.6	33	106.4	77.6
Alberta	14	107.7	71.8	48	104.1	71
Grand average	203	106.2	77.3	270	103.6	75

4. By routine checking of practices.

To date routine checking of practices, rations and other factors related to management has provided the best method of checking Station operation. It includes:—

(a) check analyses from time to time of feed mixtures.

(b) inspection of Stations and check of operator's work and methods.

(c) checking of temperatures, humidity and general condition of the piggery by means of logs. So far this has only been done at piggeries constructed by the Department.

(d) checking of results as an indication of possible trouble.

5. By special tests.

As a final check on the operation of any particular station a direct comparison may be made of the management between Stations by eliminating any differences due to differences in breeding. By this method 4 littermates of a group being placed on test are purchased and forwarded to the Station at which the management is in question. When the test is completed at both Stations a direct comparison of the effect of management is possible. This method is also the one most likely to reveal the cause of the trouble.

With the present handicap of limited facilities no attempt has been made to use this method as a routine test. It is strictly limited in its application due to the limited size of a litter, and the impossibility of shipping young pigs long distances; furthermore, results are not available until four or five months after application, during which time many groups in the Station may be affected by the faulty management. It does provide the most reliable check on management yet devised, will probably indicate management weaknesses, and is a very forceful demonstration to the feeder of any management faults.

In practice some use has been made of all the methods outlined in deciding if any particular Station is properly operated. While at the moment the routine checks are considered to be the most useful, a careful check of the scores and of the finish of the pigs is maintained currently as an indication of whether a more thorough investigation is necessary. Should an increase in unfinished pigs take place or too many sows fail in maturity index, a special check is made of that particular Station to determine possible reasons for the results. All the checks so far devised have one common disadvantage in that they consist of a backsight on groups completed. There are at the same time in the Station groups which are approaching completion, and if the management is at fault a considerable number of groups may be affected before this is discovered and corrected.

Under Station conditions the objective is to apply only reasonably good methods and rations and, as fast as funds permit, to construct buildings in which conditions will be controlled so as to give an equal chance to all groups at all Stations. No attempt is made to apply special practices or attention to any particular group.

Table 1 indicates to some extent whether or not a good job is being done at Stations on the whole. It will be noted that with the exception of the first year, there has not been a great deal of difference in the percentage of sows qualified under home or Station feeding. During the first year there was an outbreak of disease at two Stations which in all probability affected the scores of some groups tested.

THE PERSONAL ELEMENT

Personal Factor

One of the most difficult factors in management to control is the personal factor. The operator is of course limited in the kind and quality of feeds used, the number of times the pigs are fed, and in a number of the details of operation. On one point, however, he has considerable leeway, and that is in the quantity of feed supplied to any group. The instructions on this point are that all groups shall be hand full fed, but the interpretation of full feeding must be left to the judgment of the operator with the usual result that his experience and *viewpoint* determine to a very large extent the amount fed. There is also the temptation, due to the desire to produce as many good market pigs as possible, for the operator to manipulate the feed intake deliberately in order to bring about certain changes in the carcasses. That the daily feed intake can have an effect on the carcasses produced, particularly with regard to the amount of finish, was demonstrated by a comparative test conducted at two Stations in 1936. Table 4 gives a summary of these two tests.

Groups AC and AD were from the same litter, four pigs being fed at each of two Stations. Groups BC and BD consisted of two groups of the same breeding but from different litters tested at different Stations at different times. The latter test was used as a check on the former. It will be noted that group AD gave a higher slaughter test score with very little difference in feed consumption. In Group AC there were four unfinished pigs (under 1″ minimum) and one overfinished at the shoulder. In Group AD two of the pigs were overfinished (over 2″) at the shoulder with none underfinished. This is a definite indication that the pigs in

TABLE 4.—SUMMARY OF COMPARATIVE TESTS 1936–37

Code	Maturity index score	Slaughter test score	Feed consumed	No. under-finished	No. over-finished	Initial weight	Feed 70 days	Gain 70 days	Cold carcass weight	Average carcass weight
AC	105	64	420	4	1	142	926	342	623	156
AD	102	75	423	0	2	151	984	337	598	149.5
BC	102	60	418	4	0	*162	727	351	617	154
BD	111	74	431	2	1	155	773	403	589	147

*At 84 days of age.

SCORING

Code	Production	Maturity index score	Slaughter test score	Feed consumed	Length	Back fat		Balance of side			Belly grading	Total	Deduction*
						Thickness	Evenness	Ham	Middle	Shoulder			
AC	50	105	64	420 lbs.	24	2	4	8	4	3	21	64	2
AD	50	102	75	423 lbs.	24	8	6	8	6	4	19	75	
BC	55	102	60	418 lbs.	24	4	6	8	4	3	13	60	2
BD	45	111	74	431 lbs.	24	6	8	8	9	8	11	74	

*Deduction for one carcass over 160 lbs. A deduction is made of 2 points for each carcass over 160 lbs.

Group AD were better finished than in AC. On analyzing these results further, it was found that the chief difference was in the feed intake during the first few weeks of feeding. This is shown by the figures in the table of 926 lbs. of feed for the group AC and 984 lbs. for the group AD during the first 70 days at the station. This was corroborated in the check test. This test was made because the results from Station C had not been considered satisfactory and it was considered desirable not only to conduct a comparative test so as to have some definite proof to offer the operator that his methods were not all that could be desired, but in an attempt to actually find the cause of the trouble. Since the results of this test were placed before the feeder, the feed intake during the earlier period has been increased with better results at the station. The training of the two feeders concerned perhaps illustrates to a considerable degree the contention that the interpretation of full feeding is based on the previous experience of the feeder. In the case of Station C the operator had previously finished thin pigs, his profit depending on low feed consumption and maximum weight increase. The operator at Station D was a purebred breeder and fitter whose profits depended to some extent at least on the fitness and appearance of the pigs at all times.

It is realized that the personal element should be eliminated if at all possible and to that end several methods of doing so have been explored. For example, a study was made of the use of self-feeders and a few tests were conducted to determine if this method of feeding offered the solution. While the evidence accumulated has not been sufficient to justify any definite conclusion, it indicates that self-feeding has some effect on the carcasses and increases feed consumption. Another possibility which has been explored is that of supplying feeders with a schedule of daily feed intake based on past experience upon which to base their feeding. The object here would be twofold:

(a) to prevent manipulation by the feeder as far as possible;

(b) to standardize feed intake.

The figures which we have obtained to date show definitely that daily feed intake increases with higher maturity index scores and in studying the data the feed consumed every 14 days was analyzed according to maturity index ranges.

Table 5 is an extract from this data for two Stations compared to the general average for all Stations, and is an indication of the variation which exists in daily intake at different Stations for groups having the same maturity index.

With a schedule of this kind in his possession the feeder could determine reasonably well if he was feeding an average quantity of feed to all groups. It would also be possible to check the intake from time to time in order to make sure that no serious manipulation was being attempted.

It is doubtful if such a schedule could be used as a definite schedule of rate of feeding, as undoubtedly some groups of pigs would be unable to consume the required quantities and others could exceed these quantities without difficulty. It is probable that its main use would be as a guide to the feeder and the supervisor as to approximate quantities to be fed each group.

TABLE 5.—FEED INTAKE 1937–38

Maturity index	Station	Age 70–84 days	Age 126–140 days	Age 184–198 days	Average daily intake	Feed consumed per 100 lbs. carcass gain
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
95–99	Quebec	2.75	4.52	6.18	4.53	474
	Ontario	1.97	3.84	6.47	4.25	451
	General average	2.04	4.00	6.51	4.34	463
100–104	Quebec	2.58	4.86	6.15	4.59	454
	Ontario	2.09	4.13	6.74	4.37	422
	General average	2.14	4.56	6.91	4.60	460
105–109	Quebec	3.11	5.59	6.80	5.02	451
	Ontario	2.39	4.71	6.95	4.56	442
	General average	2.46	5.23	7.34	4.91	460

DISCUSSION

With more experience in Station operation, it has become more apparent that a standardization of maturity index as far as it can be controlled by feed intake is highly desirable, and it is doubtful whether a standard of qualification can be set for maximum feed consumption until the maturity index has been standardized just as are the rations and conditions under which the pigs are fed and the weight and finish at slaughter.

The two major difficulties in standardization of Station operation have been outlined. Of these two it is believed that the lack of a standard of measurement of station management is probably the more serious, as no solution is in sight. There is still much to be done in the way of construction, closer supervision, and the elimination to a greater extent of the effects of the personality of the operator before Station results can be considered as completely comparable. Most of these matters are being dealt with as fast as funds and personnel permit.

CONCLUSION

Despite the difficulties of completely standardizing Station operation, Test Station feeding of groups for Advance Registry Test affords a much more valuable method of appraising the inherent value of the breeding stock than does home feeding in which the skill and feeding ability of the breeder may have a considerable effect on the results. It is only through Test Station feeding that comparative figures of the efficiency of production as denoted by feed consumption can be obtained.

THE ANALYSIS AND INTERPRETATION OF HOG CARCASS DATA[1]

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Carcass studies are one form of progeny test. Progeny tests are a biological means of discovering the hereditary makeup of the parent animals, and are used in practical animal breeding, presumably as an aid in the selection of breeding stock. While some hereditary characteristics are relatively independent of environmental factors, many are subject to modification by non-genetic influences. In fact, in so far as a great many of the economically important characteristics of animals are concerned, only the ultimate limit of the development appears to be set by heredity, while the actually observed development is determined by conditions of feeding, management, or other environmental circumstances. Obviously, the effect of environment then may mask a true picture of the hereditary possibilities existent in the individual or group.

In addition, the breeder of hogs is faced with the fact that many of the characteristics with which he is concerned are not visible or distinguishable on the live hog. Carcass quality and peculiarities are measurable only in the slaughtered animal. Progeny tests are the only means of discovering the hereditary makeup of breeding stock in this feature, unless it is found that the development of a certain characteristic, which is visible on the live hog, is indicative of the simultaneous development of the unseen character in question.

The solution of such problems as the above facts present is complicated by the fact that no two individuals are exactly alike. Genetically, this is the result of the interaction of the thousands of genes which are involved in the genetic structure of any so-called "hereditary unit." Practically, the result is that in order to obtain a reliable measure of the hereditary constitution of a given individual, or more probably of a given family of individuals, a considerable number of individual progeny must be examined. Indeed, so many cases must be included that it becomes impossible to obtain a clear picture of the data without some organization or analysis of the figures. One of the simplest statistical procedures is the calculation of an average. An average is merely a means of describing a series of observations or figures.

Many data require more accurate description than the simple average can give, and more elaborate schemes of statistical analysis are available to one familiar with their use. The critical study of the extensive data, obtained from carcass measurements in order to make the fullest use of the information as a part of a progeny test, requires the application of some of these statistical methods. The particular scheme of analysis best suited for a given set of data depends on the answer sought, and the nature of the data. One of the real problems is to find the best method, and particularly to avoid the use of a wrong method.

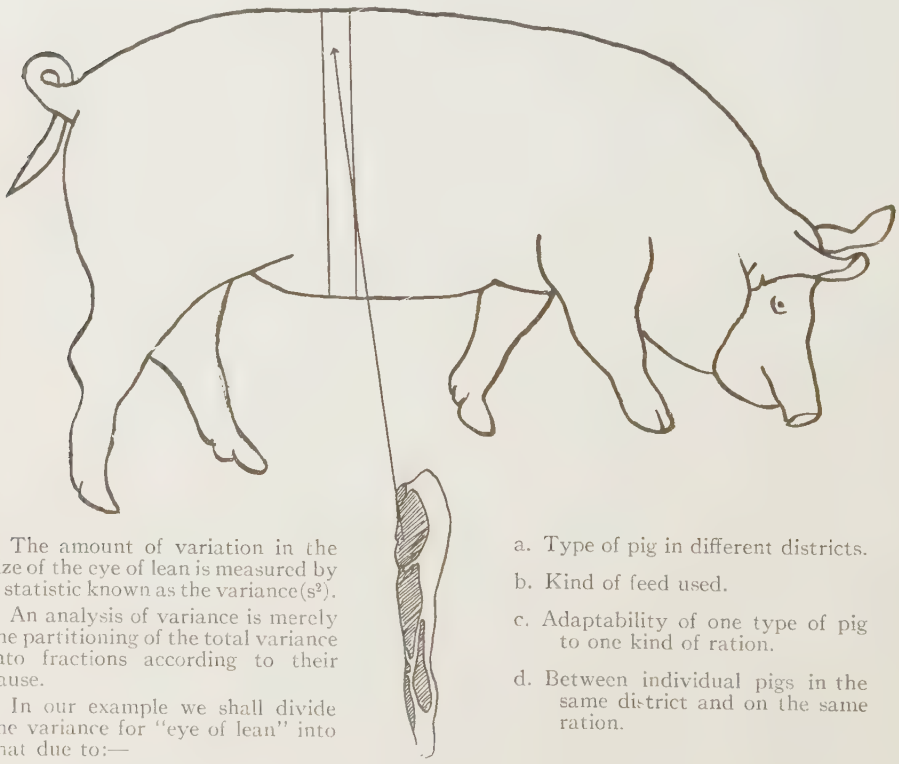
[1] An address delivered before the Ninth Annual General Meeting of the Canadian Society of Animal Production (Eastern Section) at the Central Experimental Farm, Ottawa, Ontario, on June 29, 1938.

[2] Associate Professor of Animal Nutrition.

The object of this paper is to attempt to describe in non-technical terms two statistical procedures which have been found useful in the study of typical hog carcass data, so that the layman may obtain at least some conception of how such data may yield information of use to the practical hog breeder.

In order that the discussion may be more easily followed, an actual set of data will be used, taken from a co-operative feeding trial which was conducted during 1937, involving four replicate tests each consisting of five groups of 5 pigs each. Each lot was fed a different ration, and the tests involved pigs from three different parts of the country. Among the carcass characteristics under study, the surface area of the "eye of lean" in the back rasher has been chosen in this example. This measurement is taken as indicative of the amount of lean in the bacon carcass, other tests having shown that this is a valid assumption. Any other measurement such as depth of neck fat, or size of ham could have been used to illustrate the procedure. Eye of lean was chosen partly because less is known about it, though the packers count it of considerable importance.

The approximate location of the cut from which the readings for this measurement were taken is shown in Figure 1.



The amount of variation in the size of the eye of lean is measured by a statistic known as the variance(s^2).

An analysis of variance is merely the partitioning of the total variance into fractions according to their cause.

In our example we shall divide the variance for "eye of lean" into that due to:—

a. Type of pig in different districts.

b. Kind of feed used.

c. Adaptability of one type of pig to one kind of ration.

d. Between individual pigs in the same district and on the same ration.

FIGURE 1

THE ANALYSIS OF VARIANCE

The particular objects of the first, and more or less fundamental analysis, are to learn: (1) whether or not, and to what extent, the pigs from the different parts of the country (*i.e.* different strains) showed any characteristic tendency as to the size of "eye of lean"; if they did, it would be indicated by a comparison of the averages of each test with the general average of the five tests: (2) whether or not the "eye of lean" was subject to such an environmental influence as type of ration; as in the first case, this tendency would be shown by a comparison of the averages of the five feeding groups with the general average of all lots: (3) the possible particular suitability of one type or strain of pig to one kind of ration; this, statistically, is known as interaction.

In order to facilitate the arithmetic, the figures involved are arranged as shown in Table 1.

TABLE 1.—ARRANGEMENT OF DATA (ALL FIGURES ARE SQUARE INCHES)

Station	Lots					Total and average
	I	II	III	IV	V	
	7.6	5.6	5.9	5.0	6.6	
	5.8	7.3	6.6	6.3	7.1	
A	7.2	6.3	7.3	7.7	6.1	162.3
	7.5	7.4	5.4	6.3	5.9	6.492
	6.8	5.9	6.3	7.2	5.2	
	6.9	6.1	5.8	6.7	6.5	
	6.2	7.2	6.7	6.6	6.2	
B	6.2	6.6	6.8	7.1	6.8	159.7
	6.6	6.1	5.8	5.7	4.6	6.388
	7.0	6.6	5.4	7.0	6.5	
	4.9	4.9	4.9	4.5	4.5	
	4.9	4.9	4.9	3.9	4.7	
C	5.0	4.5	4.2	4.4	6.0	121.5
	5.7	5.4	4.9	6.0	4.0	4.860
	5.2	6.0	3.6	5.4	4.2	
	5.4	4.6	5.6	5.8	5.8	
	5.6	5.8	5.1	7.0	5.0	
D	5.3	4.9	5.3	5.7	5.6	146.1
	7.9	6.4	6.6	6.7	5.8	5.844
	6.2	5.6	5.8	6.8	5.8	
Total	123.9	118.1	112.9	121.8	112.9	589.6
Average	6.195	5.905	5.645	6.090	5.645	5.896

As has already been mentioned, there is a considerable amount of variation in the figures. The reliability of any average calculated from such data will depend on how much variation there is in the figures used. It is possible that some of the variation is due to the type of ration eaten,

one ration promoting larger, and another smaller development of lean tissue. It is similarly possible that type of pig has been a factor. It is practicable to measure quantitatively either of these two possibilities. The technical name for the method is "analysis of Variance," and it is merely the partitioning of the total variability in all the data into fractions according to their causes. The figures from such an analysis are set down in typical form in Table 2.

TABLE 2.—ANALYSIS OF VARIANCE

Description	D/F	$s(x - \bar{x})^2$	s^2	s	F^* s_1^2/s_2^2	F Nec.
Total	99	88.4584				
Between sub classes	19	49.5894				
Between lots	4	5.0624	1.2656		2.60	2.48
Between stations	3	41.8320	13.9440		28.70	2.72
Interaction	12	2.6950	0.2245		2.16	2.36
Error	80	38.8690	0.4859	0.6970		

Necessary difference between lots $= \frac{.6970}{\sqrt{20}} \times \sqrt{2} \times 1.95996 = .43$ sq. in.

Necessary difference between stations $= \frac{.6970}{\sqrt{25}} \times \sqrt{2} \times 1.95996 = .38$ sq. in.

Coefficient of variation $= \frac{.6970}{5.896} \times 100 = 11.82\%$.

*F = ratio of variance for error to variance for treatment group, the larger variance being the numerator.

In this table, an explanation of the headings may be helpful. "Description" refers to the division into which the variance is divided. Here we note that "between lots" is an environmental cause of variation in size of "eye of lean." "Between stations" is largely type of pig—assuming that the blood lines and probably also the model type toward which selection has been directed are likely to differ in different districts. "Interaction" is a measure of any tendency of one type of ration to suit particularly one type of pig. "Error" is the remainder of the causes of variation,—*i.e.*, the variation between individual pigs from the same test and on the same ration. It expresses the individuality of the pig apart from any effect of ration or station. By comparing the variation between individual pigs irrespective of effects of ration, station or interaction, with that due to ration, we may learn whether ration has had any appreciable effect on the size of eye of lean. To be appreciable or measurable, the effect of ration must be greater than the effect of individuality.

D/F is an abbreviation for "degrees of freedom," and is best described in this case as the effective size of the population. Thus, by consideration of the several causes of variation, we reduce the effective size of the population from a total of 100 pigs to 80. The figure is of interest to the layman perhaps chiefly because it is the divisor used to obtain the variance (s^2) from the sums of squared deviations from the mean, $S(x - \bar{x})^2$.

The standard deviation (s) is a statistic which in "normal" populations measures the interval above and below the mean which will include $\frac{2}{3}$ of

the population. Hence $s = \pm 0.697$ indicates that two-thirds of the observations lie between 5.896 ± 0.697 or between 5.199 and 6.593 square inches. This may also be expressed in terms of odds, the chances being 2 out of 3 that any single observation picked at random will lie within this range.

The F value is merely the ratio of the variance for error to that for the given treatment or group causing variation. The larger variance is the numerator in the fraction. The necessary F value gives for the number of degrees of freedom, the amount by which the larger variance must exceed the smaller in order to indicate that the cause of the larger variance, as ration, (between lots) is significantly greater than the one with which it is compared. In this example, the effect of ration, station, and interaction have each been compared to the variance from the individuality of the pig (error). It is seen that the effect of ration is barely significant, interaction insignificant, but station very decidedly a factor in determining the size of eye of lean.

In other terms, it would appear that while there was some slight effect of the kind of ration fed, there was no evidence that pigs of one station were particularly suited to one kind of ration. But pigs from different districts may be expected to show highly significant differences in their type as to lean meat development. Referring to Table 2, we see that the pigs from Station C averaged to have an eye of lean as much as 1.5 square inches smaller than those from Stations A or B, and about 1 square inch smaller than those of Station D.

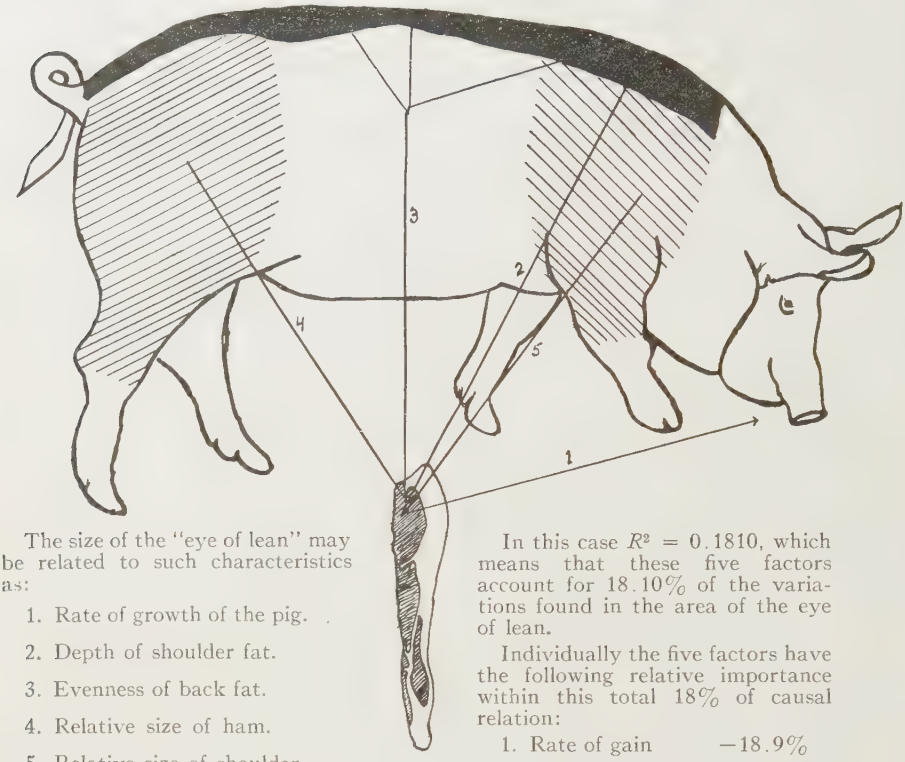
From this analysis further information is obtainable. The difference between the group means which is necessary to allow for the variations which are due to individuality may be calculated, and the figures are shown as a part of Table 2. We note that differences between means of Stations A and B are not significant, and that between rations Lot III is significantly smaller than Lots I and IV. This information may or may not be of interest, depending on the case.

CORRELATION STUDIES

Live stock judging, in no small measure, assumes that certain characteristics, usually of conformation, are indicative of other characteristics, some of which cannot be observed, and hence not selected for or against directly. Statistically, this is described in terms of correlation. Thus, we may feel that a certain type of udder indicates certain milk producing ability, *i.e.*, udder type is correlated with milking ability. Such relationships are frequently those of cause and effect, and when this is established, observance of the one may be used to predict or indicate the nature of the other.

With some, and perhaps with most characters of economic importance, the causal factors are several. Simple correlations and regressions in this case may not give a clear nor true picture. Multiple and partial correlation and regression may be used, however, from which the total effect of several causal factors, and the relative weight of these factors individually in determining variation of some characteristic under study, may be found.

Thus, as an example, we may investigate the relation of: (1) rate of live weight gain; (2) depth of shoulder fat; (3) evenness of back fat; (4) size of ham; and (5) size of shoulder, to the size of eye of lean in the bacon rasher.



The size of the "eye of lean" may be related to such characteristics as:

1. Rate of growth of the pig.
2. Depth of shoulder fat.
3. Evenness of back fat.
4. Relative size of ham.
5. Relative size of shoulder.

The extent to which all of these combined account for the variations in size of "eye of lean" is expressed by the square of the multiple correlation coefficient

In this case $R^2 = 0.1810$, which means that these five factors account for 18.10% of the variations found in the area of the eye of lean.

Individually the five factors have the following relative importance within this total 18% of causal relation:

1. Rate of gain	−18.9%
2. Depth of shoulder fat	−17.0%
3. Evenness of back fat	− 4.3%
4. Size of ham	+42.4%
5. Size of shoulder	−17.4%

FIGURE 2

The arithmetic necessary in the solution of such a problem is laborious and too extensive to present here. Suffice it to state that the data from each of these characteristics to be included are first analyzed as described under the analysis of variance of eye of lean. In addition, all possible simple correlations are determined from the error variances. Eventually the data in this example yielded figures shown in Table 3.

We note from this table that the multiple correlation coefficient $R = 0.4254$ is significant since with 6 variables R must be as great or greater than 0·4110 for odds of 19 : 1 that the relation is real. Then we learn from the square of this coefficient ($R^2 = 0.1810$) that together these 5 factors account for 18.10% of the variance of the size of eye found between the 100 hogs. Of this 18.10%, we find that 18.96% is associated with the rate of gain of the pigs while alive; 17% with depth of shoulder fat; 4.27% with evenness of back fat; 17.35% with relative size of shoulder; and finally, 42·42% is traceable to the size of the ham.

TABLE 3.—INDEPENDENT VARIABLES AND THEIR RELATIVE WEIGHT IN DETERMINING SIZE OF EYE OF LEAN OF THE BACON RASHER

Independent variable	Standard regression coefficients β	Relative weight of "beta" values	Partial regression coefficients b	Multiple correlation and squared correlation
		%	sq. in.*	
Rate of gain of pig (lbs.)	−.1373	18.96	−2.045	R^2 = .1810
Depth of shoulder fat (ins.)	−.1231	17.00	−0.381	
Evenness of back fat (ins.)	−.0309	4.27	−0.106	R = .4254
Per cent shoulder	−.1256	17.35	−0.076	Necessary (odds 19 : 1
Per cent ham	+.3071	42.42	+0.250	R = .4110

* *e.g.* 2.045 sq. in. decrease in area of eye of lean per an increase of 1 lb. per day in gain of pig, 0.381 sq. in. decrease in area of eye of lean per an increase of 1 inch in depth of shoulder fat, etc.

In a practical way, this may be summed up by saying that all 5 factors considered account for less than 20% of the differences found in eye of lean, and that of this the size of ham is by a wide margin the most important; that is, selection for large ham will more rapidly result in larger eye of lean than will selection for any other one of the 5 factors noted. From the b values, we learn that an increase in ham of 1% will lead to an increase of 0·25 square inches in the size of eye of lean in the rasher. While the rate of gain appears important from the large b value, it will be remembered that the interpretation is that an *increase* in rate of gain of *1 pound per day* would lead to a decrease of 2.045 square inches in eye of lean. Such an increase in daily gain will seldom be met under average conditions. In this trial, the greatest difference in daily gains between lot averages was 0.11 lbs. and between stations was 0.07 pounds. Taking individuals, two-thirds of the pigs had daily gains within ±0.3639 pounds of the general average.

Thus we have in correlation a method of particular value in studying the data of hog carcasses. For example, the relative importance which should be given the various carcass measurements in a scoring system, or the probable effectiveness of selection of stock according to certain characteristics in the hope of obtaining excellence in some characteristic which cannot be directly observed, may be aided by the proper application of this statistical method.

In conclusion, a warning may be in order to the effect that statistics is not a substitute for poor or unreliable data. To be most efficient, and indeed to be useable at all in some cases, statistical treatment begins with, and depends on, the design of the experiment. Thus, it may not be possible to return to the forgotten data of yesterday and with this new tool in hand, emerge with answers to questions only asked to-day.

A STUDY OF FACTORS INFLUENCING SWINE CARCASS MEASUREMENTS[1]

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When the Advanced Registry policy for swine was started the carcass measurements included were those which it was thought would best demonstrate actual differences in the pigs or the strains of pigs which Canada was developing. A survey, which was published in 1937, of the results of the pigs tested under the policy from 1929 to 1934 on the Dominion Experimental Farms revealed an improvement in the pigs, part of which it was felt could be attributed to the selection of breeding stock on the basis of Advanced Registry data. However, the inheritance of the carcass characteristics was not investigated in the survey, nor has proof of such inheritance as yet been shown. The present paper includes an analysis of certain of the data collected on pigs tested at the Testing Stations in 1937, and deals with the factors affecting some of the carcass characteristics and the relationships which exist between the measurements.

The fact that a new carcass score is being developed for the Advanced Registry adds interest to this investigation, in that previous studies demonstrated that certain measurements of bacon hogs are closely associated with weights. This association was also shown by Davidson *et al.*, 1937, (1) in a score proposed for porker and bacon pigs. It is intended in the present study to determine the extent of this relationship and to present regression coefficients to indicate the amount of the changes in the measurements of the various characters with changes in weight.

Through the co-operation of Messrs. Peterson and Lefebvre of the Production Services of the Dominion Department of Agriculture, the records of the pigs tested in 1937 at the Pig Testing Stations were made available. It was hoped that in order to investigate boar differences a sufficient number of groups of three or more litters sired by the same boar might have been tested at the various stations. Unfortunately, this was not the case at two of the stations, and groups of two litters sired by the same boar had to be included. The data finally used for analysis included 81 litters, made up as follows: Charlottetown, P.E.I., 6 litters, by two boars with three litters each; Aulac, N.B., 19, five boars represented by 5, 4, 4, 3 and 3 litters; Princeville, Que., 13, three boars with 6, 4 and 3 litters; New Hamburg, Ont., 15, five boars with 5, 3, 3, 2 and 2 litters; Winnipeg, Man., 9, two boars with 7 and 2 litters; Saskatoon, Sask., 7, three boars with 3, 2 and 2 litters; and Edmonton, Alta., 12, with four boars with 3 litters each.

The data taken for each sow or litter included carcass score, maturity index, production, and feed consumed per 100 lb. carcass gain, while for each of the four pigs representing each litter the following data and measurements were procured: age in days; cold carcass weight; length of side; shoulder, back and loin fat; minimum and maximum belly; percentage of ham, middle and shoulder; length and width of the cross section of loin muscle and the product of the length by width. Thus, the population

[1] Paper delivered before the Ninth Annual General Meeting of the Canadian Society of Animal Production (Eastern Section) at the Central Experimental Farm, Ottawa, Ontario, on June 29, 1938.

[2] Assistant Animal Husbandman (Swine).

consisted of 81 sow measurements and 324 individual pig measurements. As the details involved in collecting carcass measurements under the Advanced Registry policy were published in a previous paper (7), space will not be taken here for their discussion.

METHOD OF ANALYSIS

The analysis of the data followed closely that proposed by Dr. Crampton in the preceding paper in this series. The analysis of variance for the 324 pig measurements was sub-divided into "between stations", "between boars within stations," "between sows within boars" and "within sows". The latter is the smallest division of the variance obtainable, being that "between pigs" and is used as the "error". The "between station" variance measures the differences between the station averages, which might be due to environmental conditions or breeding differences in the pigs in different sections of Canada. The "between boars within stations" is that portion of the variance attributable to the differences between boars at the same station or after the variance "between stations" has been taken out. The "between sows within boars" is the variance between the averages of the sows with the "between station" and "between boars within station" variability deducted, or in other words, it is a measure of the variability between sows bred to the same boar at any one station. With such a division of the variance it is possible to measure the significance of the "between station", "between boar", and "between sow" variability over that "between pigs"; that is, whether or not the differences in pig measurements are due to differences in the pigs at different stations or in different districts in Canada, or are boar or sow differences which may be attributed to inheritance.

Further, with this division of the variance it is possible to compare the variability due to "between stations" with that "between boars within stations" to decide whether the former is significantly greater; that is, whether the differences between stations is not merely such as might have been expected from the differences in boars within districts. Similarly, the "between boars within stations" variance can be compared with that "between sows within boars" to ascertain whether the boar difference is not merely due to the fact that different sows were mated with different boars.

With the 81 sow or litter measurements, the analysis of variance was divided into "between stations", "between boars within stations" and "within boars", the latter also being the variance between sows or "error".

Correlations were calculated between a number of characteristics and with the pig measurements the "within sow" (between pigs) variance was used, while with litter measurements the "within boar" (between sows) variance was used.

RESULTS AND DISCUSSION

A comparison is shown in Tables 1 and 2 of the station averages of the data used in this study and the general station averages for all pigs tested at the various stations in 1937. It is immediately apparent that the averages of the data used closely approximate the general station averages. The Standard Deviations (S.D.) and Coefficients of Variability (C.V.) associated with the carcass score, maturity index, and feed to gain ratio of sows are also shown in Table 1 along with S.D. and C.V. of the individual pig measurements.

TABLE 1.—STATION AVERAGES AND COEFFICIENTS OF VARIABILITY "BETWEEN SOWS" AND "BETWEEN PIGS"*

—	Charlottetown, P.E.I.	Aulac, N.B.	Princeville, Que.	New Hamburg, Ont.	Winnipeg, Man.	Saskatoon, Sask.	Edmonton, Alta.	General Average	S.D.*	C.V.* %
No. pigs	24	76	52	60	36	28	48	324		
Carcass score	74.33	69.21	79.38	81.33	77.44	78.29	72.42	75.64	7.37	9.74
Maturity index	102.0	103.1	107.8	100.5	104.9	103.29	108.5	104.3	5.44	5.22
Feed per 100 lb. carcass gain	486.3	495.1	445.8	448.7	446.7	450.4	472.1	465.3	22.85	4.91
Carcass weight (cold)	149.1	152.3	151.8	153.4	148.9	155.8	152.9	152.2	5.36	3.52
Length of side	31.87	30.41	30.76	31.29	30.58	32.09	30.97	30.98	.642	2.07
Depth of shoulder fat	1.908	1.955	1.921	1.712	1.878	1.754	1.896	1.866	.169	9.05
Depth of back fat	.996	.972	1.165	.977	1.006	1.036	1.065	1.029	.071	6.87
Per cent ham	23.75	23.74	24.71	24.13	24.21	24.09	23.99	24.09	.786	3.26
Per cent middle	47.84	47.25	47.71	47.91	47.87	47.78	47.93	47.70	1.094	2.29
Per cent shoulder	28.41	29.01	27.58	27.96	27.92	28.13	28.08	28.21	.843	2.99
Length of loin muscle	2.750	3.042	3.350	2.770	2.856	3.157	2.908	2.989	.182	6.09
Width of loin muscle	1.458	1.774	1.879	1.640	1.692	1.589	1.637	1.697	.164	9.66
L × W of loin muscle	4.027	5.425	6.304	4.554	4.833	5.026	4.751	5.101	.589	11.56

* Standard Deviation and Coefficient of Variability "between sows" for carcass score, maturity index, and feed per 100 lb. carcass gain; and "between pigs" for others.

TABLE 2.—GENERAL AVERAGES OF STATION-FED HOGS, 1937

	Charlottetown, P.E.I.	Aulac, N.B.	Princeville, Que.	New Hamburg, Ont.	Winnipeg, Man.	Saskatoon, Sask.	Edmonton, Alta.	General Average
No. of sows tested	19	28	44	75	23	33	48	270
Carcass score	73.00	69.61	76.93	77.20	78.22	77.61	71.02	75.11
Maturity index	103.9	103.0	105.1	101.0	104.9	106.4	104.1	103.6
Feed per 100 lb. carcass gain	497.1	503.3	454.0	447.9	461.2	466.6	473.5	466.4
No. of carcasses measured	75	110	172	292	88	129	191	1057
Carcass weight (cold)	149.5	152.8	150.4	153.1	149.5	154.8	151.6	152.0
Length of side	31.60	30.43	30.82	31.32	30.94	31.79	30.77	31.09
Depth of shoulder fat	1.963	1.967	1.912	1.716	1.869	1.771	1.877	1.840
Depth of back fat	1.028	.993	1.119	.971	1.027	1.052	1.030	1.027
Per cent ham	23.72	23.88	24.68	23.94	24.13	24.16	24.04	24.10
Per cent middle	48.24	47.29	47.82	47.63	47.95	47.98	47.73	47.74
Per cent shoulder	28.04	28.83	27.60	28.43	27.92	27.86	28.23	28.16

It is interesting to note that the standard deviation of 7.37 and the coefficient of variability of 9.74% in carcass score follow very closely similar calculations (7.44 and 10.5 respectively) made on the data from the Experimental Farms' pigs examined two years ago. It would seem then, if the data used in these two studies can be considered as representative of Canadian hogs, that carcass score varies about 10% due to unaccounted-for differences between sows, or that this figure is the general variability of the carcass score. This variability might further be interpreted to mean that small differences between carcass scores should be discounted in the selection of superior strains. The new carcass score proposes to evaluate the individual carcasses of a litter group and when this has been in effect for a few years it will be possible to measure the variability between pigs of a litter and to select and breed from strains which produce consistently high quality carcasses.

ANALYSIS OF VARIANCE

The variance or M.S. (mean square) of the sow or litter measurements are shown in Table 3.

Table 3.—Variance or M.S. of characters (between sows)

	Between stations	Between boars within stations	Within boars within stations (between sows)
Degrees of freedom	6	17	57
Carcass score	277.86*†	86.64	54.29
Maturity index	108.35*	79.81*	29.58
Feed per 100 lb. carcass gain	5653.74*‡	771.35	522.33

* Significant over "between sows" variance with $P = .01$, F necessary "between stations" = 3.14
† Significant over "between boars within stations" variance with $P = .05$, F necessary = 2.70.
‡ Significant over "between boars within stations" variance with $P = .01$, F necessary = 4.10.

Carcass Score

There is shown a significant difference in carcass score "between stations", the variance due to "between stations" being significantly higher than that due to "between boars within stations" with P = 0.05, or odds of 19 to 1 against this finding being due to chance alone. This result is to be expected from observation, and by referring to Table 2 it will be noted the sows tested at Aulac, N.B., averaged 69.6 in carcass score as compared to 78.2 for those tested at Winnipeg, or to Table 1 where the same general differences between districts exist. The results further indicate that in these data there were no significant differences between boars at the same station in carcass score.

Maturity Index

Although the variances due to "between stations" and "between boars within stations" in rate of maturity are shown to be significant over the "between sow" variance, the station variance is not significant over that due to different boars at the same stations, and thus cannot be considered

to indicate true station differences. However, the significant differences between boars at the same station would substantiate the acknowledged fact that certain strains of pigs are definitely more rapid in rate of maturity.

Feed to Carcass Gain Ratio

In feed required per 100 pounds of carcass gain there is definitely a wide difference in the pigs fed at the different stations in Canada. With all testing stations following a like feeding programme it is reasonable to suggest that part of this difference, at least, is due to an inherent difference in the hogs of the different provinces, while some, no doubt, may be attributed to the personal factor of different feeders. From the averages in Table 1 it is indicated that the pigs at Aulac, N.B., and Charlottetown, P.E.I., were noticeably higher, and those at Edmonton somewhat higher in feed required per 100 pounds carcass gain than those of the other four stations. In the general averages in Table 2 the first two mentioned still top the list, while the Winnipeg and Saskatoon feed to carcass gain ratios are somewhat higher than shown in the data analyzed.

These data did not show any significant difference between boars in feed utilization.

The variance or M.S. for the measurements of the 324 pigs is presented in Table 4.

TABLE 4.—VARIANCE OR M.S. OF CHARACTERS (BETWEEN PIGS)

	Between stations	Between boars within stations	Between sows within boars	Within sows (between pigs)
Degrees of freedom	6	17	57	243
Carcass weight	182.03*	70.40*	48.29*	28.76
Length of side	15.35*‡	3.03*‡	1.12*	.412
Depth of shoulder fat	.438*†	.133*‡	.033**	.028
Depth of back fat	.247*†	.076*‡	.032*	.005
Per cent ham	5.51*	2.24*‡	.865*	.617
Per cent middle	3.63*	6.93*†	3.12*	1.20
Per cent shoulder	12.88*†	4.63*‡	1.94*	.711
Length of loin muscle	2.16*†	.071*	.058*	.033
Width of loin muscle	.703*‡	.071*	.057*	.027
L × W of loin muscle	22.92*‡	1.15*	1.05*	.347

** Significant over "between pigs" variance with $P = .05$.

* Significant over "between pigs" variance with $P = .01$. F necessary "between stations" = 2.89; between boars within stations = 2.03; and "between sows within boars" = 1.18.

† Significant over the "between boars within stations" or "between sows within boars" respectively, with $P = .05$; F necessary "between stations" = 2.70, "between boars within stations" = 1.80.

‡ Significant over the "between boars within stations" or "between sows within boars" respectively, with $P = .01$; F necessary "between stations" = 4.10, "between boars within stations" = 2.30.

Carcass Weight

The only variance of significance in carcass weight in Table 4 is that of the weights of the pigs from different sows bred to the same boar. Significance is indicated for the variance due to "between stations". "between

boars within stations", and "between sows within boars" over the "between pig" variance but as the between station variance is not significant over that due to between boars at the same station, nor the between boar variance significant over that between sows bred to the same boar the only real differences would seem to exist between the carcass weights of the pigs of different sows by the same boar. With the policy of marketing pigs when they show sufficient finish, even over a narrow range of weights, this would mean that different sows' pigs reach that finish at different weights.

Length of Side

There are several factors which definitely influence the length of pigs. First, there is a significant difference in the length of the carcasses of the pigs from different sows bred to the same boar. Over this, the "between boars within stations" variance is significantly higher than that due to "between sows within boars"; that is, there is a difference in length between the pigs sired by different boars at the same station. Over and above this, the pigs in different sections of Canada differ in length as shown by the significant variance due to "between stations" over that "between boars within stations". Thus, it may be said that while the pigs differ in different sections of Canada in length, nevertheless, by scoring this characteristic actual boar and sow differences are being indicated.

Lush of Iowa (4), in an extensive study of the results from pig testing in Denmark investigated differences between the various testing stations in length of side, thickness of back fat, thickness of belly, daily gain, and yield of export bacon. He found important differences between the stations in daily gain and in thickness of belly, and stated that while the other three characteristics showed differences, they were too small to be important. In explanation he further stated that such differences might arise from differences in management at the different stations or differences in the general characteristics of the swine population in the various parts of Denmark. Regional differences in the kind of breeding stock might cause differences in the averages at the various testing stations, as each breeding centre normally sends its test pigs to the same station. Lush did not arrive at a decision between these two hypotheses, but the same circumstances exist in Canada, although the wider range of conditions and the expanse of the Dominion might lead to the conclusion that differences exist between the strains of pigs in the districts at which pigs are being tested across Canada.

Depth of Fat

The results of the analysis of variance of the depth of shoulder and back fat show significant differences "between stations" over "between boars within stations" although only at the lower level, *i.e.*, $P = 0.05$, and highly significant differences between boars at the same station. Between sows the differences in back fat are highly significant, while the variance of shoulder fat only exceeds that between pigs with $P = 0.05$.

Percentage Cuts

In attempting to develop pigs with the desirable balance of 25% ham, 50% middle, and 25% shoulder, Canadian pig breeders would seem

to be bringing about some reduction in percentage shoulder, in that the Experimental Farms' pigs tested between 1929–34 averaged 29% in this character, and those tested in 1937 at all the Testing Stations, about 28%. With these data it is shown that percentage shoulder is the only measure of the balance in which there are significant differences "between stations". Upon referring to Tables 1 and 2 it will be noted the percentage shoulder of the Quebec hogs is consistently lower than those of the other provinces, although all are still considerably above the percentage desired. Real differences are also shown between boars and between sows and it would seem that with careful selection improvement in balance might be expected.

Loin Muscle

One of the reasons for investigating the possibility of revision of the carcass score of sows tested under the Advanced Registry Policy was the desire to include in it some measure of the lean in the carcasses. Considerable study has been made of this characteristic, and Davidson *et al.* (1) contend that a measure of the depth or width of the cross section of the loin muscle gives not only a relative indication of the lean in a carcass but is also evidence of the stage of development in that this muscle develops first in length, then in width. From studies conducted by Sinclair (5, 6) at Edmonton and Crampton (2) at Macdonald College, it was shown that the product of the length and width was more closely correlated with the actual area of the muscle than either of the individual measurements. Several high correlations (ranging between 0.8 and 0.9) calculated from data (unpublished) collected at the Central Experimental Farm over the past three years substantiate this finding. As it was also shown that the area of the loin muscle was an indication of the percentage lean in the rasher, these measurements have been taken in connection with the Advanced Registry slaughter tests for the past year, preliminary to their being studied for inclusion in the carcass score.

The three measurements, that is, the length, width, and product of the length and width of the cross section of the loin muscle, show significant station and sow differences, but the "between boar within station" variance was not significant over the "between sow within boar" variance. Thus, it would seem that Canadian pigs differ in different sections or at the various stations in respect to the amount of lean meat carried as measured by the product of the length and width of the loin muscle. Also, different sows produce pigs varying significantly in this characteristic. The pigs tested at Princeville, Que., were considerably higher in this measure of lean than those tested at the other stations.

It would seem, therefore, that there exist differences between the pigs from different sows in all the characters studied and between the pigs from different boars in length of side, depth of shoulder and back fat, and percentage ham, middle and shoulder. There were also highly significant differences between the pigs tested at the different stations in length of side, width of loin muscle, and the product of length and width of loin muscle, and significance, with $P = 0.05$, between the stations in depth of shoulder and back fat, percentage shoulder and length of the loin muscle.

CORRELATIONS

As intimated at the outset, the association between some of the carcass measurements was investigated, and the correlations calculated are presented in Table 5.

TABLE 5.—CORRELATIONS AND REGRESSIONS

x	y	Co-variance $S(xy)$	Correlation r_{xy}	Co-variance $\frac{\sigma 2_x}{b^1}$	Co-variance $\frac{\sigma 2_y}{b^2}$
Carcass weight (1)	Length	324.66	.388*	.047	3.243
	Shoulder fat	59.97	.273*	.009	8.704
	Back fat	57.41	.624*	.008	47.446
	L × W loin	96.68	.126	.014	1.145
Length (1)	Shoulder fat	−1.51	−.057	−.015	− .219
	Width of loin	2.22	.087	.022	.338
	L × W of loin	−16.89	−.184*	−.169	− .200
L × W of loin (1)	Shoulder fat	−4.98	−.207*	−.059	− .723
Feed per 100 lbs. carcass gain (2)	Carcass score	−702.63	−.073	−.024	− .227
	Maturity index	−3130.25	−.442*	−.105	−1.856

(1) Calculated using the "between pig" variance, 243 D/F; with 200 D/F r necessary for significance with P of .05 = .138; P of .01 = .181.

(2) Calculated using the "between sow" variance, 57 D/F; with 50 D/F r necessary for significance with P of .05 = .273; P of .01 = .354.

(*) Significant.

Since it would seem natural that carcass measurements should increase with growth or weight, the extent of the association in the somewhat narrow range of bacon weights is particularly interesting. The regressions indicate the amount the length of side, and depth of shoulder and back fat, which are significantly correlated with weight, would be expected to change with changes in weight. It is indicated that with a 10-pound increase in weight, length of side might be expected to increase 0.47 inches, shoulder fat, 0.09 inches, and back fat, 0.08 inches. This range follows very closely that proposed in the new carcass score. The desired length of side, for instance, of pigs ranging in carcass weight from 145¼ to 155 pounds is 30.5 inches, while those weighing from 155¼ to 165 is 31 inches.

The correlation between weight and the length × width of the loin muscle is not significant with 200 degrees of freedom, the nearest figure in statistical tables, but with the 243 degrees used it approaches the significant point. In another study (unpublished) of this relationship with 92 hogs tested at the Central Experimental Farm there was indicated a significant correlation.

Although Jepersen and Madsen (3) in a study of Danish progeny records report a negative correlation between length of side and thickness of back fat, *i.e.*, the longer the pig the thinner the back fat, Sinclair and Murray (5) found no significant association in Canadian pigs between these two measurements. The correlation calculated with these data between length of side and depth of shoulder fat is not significant.

In interpreting the simple correlations care should be taken to study the characters involved before drawing any definite conclusions of cause and effect. Hence, the significant correlation noted between length of side and the product of the length and width of the loin muscle might be affected by the interrelationship of weight on length and the area measurement. In calculating the correlations the corrected sums of the cross-products between pigs were first totalled by stations, and hence it was possible to see whether the relationships were consistent in all stations. In most of the significant correlations this was the case, but in the latter the Quebec hogs with their large areas of loin and medium length showed the negative result, while the other stations showed little tendency to association of significance. Also,, the association reported between area of loin (the length multiplied by the width of the cross-section of the loin muscle) and shoulder fat may be linked up with the fact that heavier pigs also have a greater depth of shoulder fat and possibly more lean. However, it would seem that this correlation can be interpreted independently as it is shown that pigs with more shoulder fat carry less lean and this should naturally be the case.

As in the former study of Experimental Farms' pigs, these data show no relationship of feed per 100 pounds carcass gain and carcass score. Thus, the economy of feed consumption seems to have little effect on the type of the carcasses produced. The rate of maturity and economy of feed utilization, however, are correlated to a significant degree, r being -0.442, indicating that the faster the pigs reached maturity the less feed was required per pound of carcass gain. This might be explained in that the longer a pig is carried to reach finished weight the greater is the amount of feed required for maintenance.

SUMMARY

A representative group of the pigs tested in 1937 at the seven Advanced Registry Pig Testing Stations across Canada were studied to investigate the factors influencing carcass measurements and some of the relationships existing between the measurements.

In the measure of sows' relative ability to produce economical and quality pigs, there were significant differences between the testing stations in average carcass score and the amount of feed required per 100 pounds carcass gain. Differences were also noted between boars or the strains of pigs sired by different boars in rate of maturity.

There were indicated significant differences in the pigs sired by different boars in length of side, depth of shoulder and back fat, and in balance of side as represented by the percentages of ham, middle and shoulder. Important differences were also apparent between the testing stations, which might mean between strains of pigs in different sections of Canada, in length of side and the product of the length and width of the cross section of the loin muscle, the latter being taken as a measure of lean in the carcass. Less significant differences were shown between the stations in depth of shoulder and back fat, and in percentage of shoulder. It would seem that the uniformity of these characteristics across Canada might be improved as significant differences between sows in all the carcass measurements investigated were also indicated.

In simple correlations it was noted that length of side and depth of shoulder and back fat increased with increases in weight, while the area of lean or the product of length and width of the loin muscle decreased with increased depth of shoulder fat.

The amount of feed required per 100 pounds carcass gain decreased as the rate of maturity increased.

The study indicated that by measuring pig carcasses under a scheme such as the Advanced Registry, differences in the swine population can be demonstrated and improvement effected by judicious selection.

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THE MARKET VALUE OF CANADIAN BACON[1]

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In submitting even a brief statement on the present quality of Canadian bacon, it would seem desirable to review briefly what has been accomplished more recently in the improvement in quality of our bacon, as well as to define our present position in respect to quality as compared with our several competitors on the British market. It may be conservatively stated that in respect to butchering, curing, pack, flavour, general appearance and even freshness, our bacon at the present time is equal to any on the British market. This has been made possible by co-operative effort between exporting packers and the Dominion Department of Agriculture. It has been accomplished through the medium of a committee consisting of exporting packers and departmental representatives which is known as the Bacon Standards Committee. A bulletin entitled *Canadian Standards for the Preparation of Wiltshire Sides* is available to all exporting packers. This includes instructions relating to standard practices that have been agreed upon in respect to pre-slaughter handling of live hogs, killing operations, singeing, butchering, curing, baling and general sanitation, and loading. This has resulted in a product of uniform appearance coming from all packing plants. In addition to this, particular attention has been given to the providing and maintaining of uniform temperature while in transit, both in railway cars and steamships, as well as supervision of loading and unloading at docks, both at ports of export and in Great Britain. The net result has been the practical elimination of complaints in respect to slime and taint that used to be somewhat prevalent, as well as placing a uniform product from all plants on the British market.

While the colour, appearance and freshness of our product is generally satisfactory at time of arrival and unbaling in England, our bacon is at times criticized for a tendency to discoloration after cutting. While this does not affect the eating quality, it does detract from the appearance, giving rise to suspicion of taint. The National Research Council is now working on this problem and have a program of study and investigational work under way in the hope of determining the cause and providing suggestions as to how this source of trouble may be modified or eliminated.

The measure of success that has resulted from our attention to processing, handling and shipping of our bacon is gratifying, but we are still considerably short of attaining the standard of quality comparable to that supplied by our competitors. While weight is hardly a question of quality, suitability of weight is an important factor in relation to price. During 1937, only 57.88% of all the Wiltshire exported were of sizeable weights; 27.65% were below 55 lbs., and 14.33% were over 65 lbs. For five months of the present year, the percentage of sizeable was 61.72%, a slight improvement over last year. The percentage of light weights has decreased to 17.38%, but the overweights increased to 20.88%. At the

[1] An address delivered before the Ninth Annual General Meeting of the Canadian Society of Animal Production (Eastern Section) at the Central Experimental Farm, Ottawa, Ontario, on June 29, 1938.

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present time a study is being made in all packing plants to devise if possible a more efficient method for selecting singers for export Wiltshires. If all hogs could be singed and those suitable for Wiltshires selected later, the problem would be materially simplified. There are, however, certain objections in the domestic trade to singed hogs.

While this study of the method of selecting Wiltshires is being made with a view of insuring, in so far as possible, that all suitable hogs will be utilized, the real problem lies in the lack of sufficient carcasses of suitable weights for making sizeable Wiltshire. Sizeable Wiltshire can only be made from carcasses weighing from 143 to 168 lbs. hot carcass weight. While accurate figures are not available, an analysis of carcass weights on some 580,000 hogs rail graded this year to date and special tests made from time to time would indicate that not more than 45% of the total hogs marketed come within these weights. This fact in itself indicates the necessity of having more hogs marketed within desirable weights if we are to improve materially the weights of our export Wiltshire.

During 1937, only 59.70% of the total exports to Great Britain were in the form of Wiltshire sides; 21.64% were hams and gammons, and 18.64% were other cuts. For January to May, inclusive, of the present year, 60.72% were Wiltshire; 19.26% hams and gammons, and 20.01% other cuts. Reference is made to our shipments of cuts because with such a substantial volume going forward, they become an important factor in influencing the quality and reputation of our bacon products on the British market. There always has been a certain volume of cuts exported, but the present large volume is almost directly due to not having sufficient hogs suitable for Wiltshire sides. Some of these cuts are from good type hogs that could not be exported as Wiltshires owing to bruises on other portions of the carcasses, but in the main they are from inferior quality carcasses not suitable for Wiltshires. They are not subject to grade standards and, further, owing to the fact that at certain times a considerable volume are subject to storage they are obviously not comparable in quality to fresh cut Wiltshire in Great Britain. These cuts are sold in competition with fresh cut Wiltshire in Great Britain and certainly do not enhance the reputation of our bacon. The justification for exporting the present volume of cuts is to maintain the general volume when there are not sufficient hogs suitable to make Wiltshires. This is obviously a sound policy for the time being, but indicates the necessity for carrying forward our improvement program so that the volume of cuts can be gradually reduced.

The statement that there is not sufficient volume of hogs suitable for export requirements in the form of Wiltshire may require some clarification or explanation. Reference is frequently made to the number of Selects marketed annually, as compared with our total export of Wiltshire, and to a person not familiar with the trade, it is a very logical comparison.

For the first five months of the present year, there were 443,442 Selects or "A" Grade carcasses graded in Canada. Our total export of Wiltshires during this period was equivalent to 347,762 hogs or 96,680 less than our total Selects and "A" Grade carcasses. This included all grades, selections and weight ranges of Wiltshires exported, but the sizeable 55–65 "A" Grade Wiltshires only amounted to 213,700 hogs. Briefly stated, the main reason

that there are almost twice as many Selects as our total exports of "A" Grade sizeable Wiltshire is because the standard for export Wiltshires is much more exacting than the standard for Selects or "A" Grade carcasses. The following reasons, however, will explain why many Select or "A" Grade carcasses are not available or suitable for export as Wiltshire:

A considerable number of Selects are purchased and processed by packers and butchers not in the exporting trade, but doing a purely domestic business.

A certain percentage, or approximately 20%, must be de-graded or eliminated on account of bruising.

A certain percentage, varying according to the localities and seasons, are rejected owing to soft or oily fat.

The weight requirements for Select hogs alive is 180–220 lbs. weighed off cars. Owing to variations in dressing percentage, carcasses from Select hogs may weigh 135–176 lbs., whereas, as previously pointed out, sizeable Wiltshires can only be secured from carcasses weighing from 143 to 168 lbs. While this does not affect the quality, it removes a considerable percentage from the sizeable weight range.

Another factor restricting the quantity of bacon for export is that at some plants Wiltshires can only be selected from kills on certain days owing to the program that must be followed in conforming with weekly shipping schedules.

These factors all eliminate or make unavailable for export a certain percentage of Select hogs.

As previously pointed out, there is a very definite difference in the standards prescribed for Selects or "A" Grade carcasses as compared with "A" Grade Wiltshires. It is obvious that no very definite carcass standards can be applied to Selects graded alive; therefore, for the purpose of comparison the standards for "A" Grade carcasses and export Wiltshires are used. In this connection it should be pointed out that as long as live grading and carcass grading are carried on together, competition in buying hogs necessitates that there be a fairly close relation between Selects and "A" Grade carcasses.

"A" Grade carcasses must weigh from 140 to 170 lbs. hot carcass weight and are permitted a maximum shoulder fat of 2 inches and a maximum loin fat of $1\frac{1}{2}$ inches. It should be noted that there is no limitation on the variation of back fat, and a carcass measuring 2 inches on the shoulder and $\frac{7}{8}$ inch on the loin can qualify for "A" Grade although having $1\frac{1}{8}$ inches variation. Export standards for "A 1" or leanest sizeable must not have over 2 inches shoulder fat, the same as "A" Grade bacon, but not more than $1\frac{1}{4}$ inches loin fat as compared with $1\frac{1}{2}$ inches for "A" Grade carcasses. "A 2" or lean export Wiltshires can carry up to $2\frac{1}{4}$ inches shoulder fat and not over $1\frac{1}{2}$ inches loin fat. Recent tests have been made to ascertain the percentage of Wiltshires, and the results are strongly indicative of a major weakness in our commercial hogs, which naturally affects the question of quality in our export bacon.

As has already been pointed out, weights for "A" Grade carcasses are 140 to 170 lbs. whereas, sizeable Wiltshires require carcasses from 143 to 168 lbs. Owing to this difference in weight requirement, 10.4% of the

"A" Grade carcasses would not make sizeable Wiltshire. 8.1% of the "A" carcasses were eliminated for having over 2 inches shoulder fat or over $1\frac{1}{2}$ inches loin fat or less than $\frac{7}{8}$ inch minimum. This must be attributed to error in grading since these measurements were outside the requirements laid down for the "A" grade. These two factors eliminated 18.5% from "A" Grade sizeable Wiltshire.

An essential requirement for good Wiltshires is a reasonable uniformity in back fat covering. The balance of the carcasses were, therefore, checked from the standpoint of uniformity of back fat with Wiltshire requirements in mind. It was considered that anything over $\frac{3}{4}$ inch variation between maximum and minimum back fat might be considered undesirable. In applying this standard to the balance of the "A" Grade carcasses, it was found that 50.2% had over $\frac{3}{4}$ inch variation of back fat. Of the remaining carcasses, 22.0% qualified for "A" or "leanest", and 19.7% for "A2" or "lean" selection of "A" Grade Wiltshire. These results indicate very definitely a fault in our commercial hogs when a definite standard of back fat uniformity is applied. While it is true that a considerable percentage of the carcasses that have over $\frac{3}{4}$ inch variation in back fat is being exported to-day as "A" Grade Wiltshire, they indicate along with the other reasons cited why a substantial proportion of Selects and "A" Grade hogs is not suitable for our present grade of export Wiltshire.

One would not like, however, to leave the impression that the Wiltshires that are being exported are not of high quality. The facts are that 89.0% of our total Wiltshire exports are of "A" Grade quality. While it is true that only 54.88% of the "A" Grade are sizeable, the quality is good and if the weights could be corrected, it would materially improve the uniformity of our export product.

As stated at the outset, the condition, appearance and flavour of our bacon must be considered very satisfactory and the grade, selection and quality that are being exported are meeting with general satisfaction on the British market. The general type, the tendency to heavier shoulder, slightly higher percentage of fat in many carcasses, and the lack of uniformity in fat covering appear to be the essential difference between the Canadian bacon and some other bacon being sold on the British market. While this does not affect the flavour and eating quality of the bacon in so far as the consumer is concerned, it does very definitely influence the cut out value to the retailer.

In conclusion it should be said that the broad programme of swine work we now have under way, including a wider application of Advanced Registry and Test Station breeding and feeding principles to production, along with further study of practical and scientific means to improve our marketing technique, should do much to solve our present problems and thereby raise the standards of our bacon products.